AN INQUIRY
INTO SOME ASPECTS OF DECISION MAKING
IN CAPITAL INVESTMENT

A THESIS

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CHAPTER I

INTRODUCTION

Perspective and Justification of the Study

Broadly speaking capital investment, from the point of view of an enterprise, may be defined as the act of committing liquid dollars into physical form - in land, building, plant and equipment, inventories etc. - to help the operations and objectives of the enterprise. Capital investment is the heart of business operations. For, no business can come into existence nor grow without capital investment. One of the important obligations of the management is to account for such investments through annual financial statements.

Of the totality of decision-makings in the management process, those relating to capital and capital investment would generally be by far the most frequent and atonce the most difficult and unique. The reason for frequency is obvious. Every time the management decides on retention of earnings, for example, - and this is an annual affair - it is involved in this type of decision - directly or indirectly. Also, capital outlays are spread over time generally, and overlap through time. Since capital investment decision, by its very nature, has to do with allocation of limited liquid funds amongst rival projects yielding results far into the future, the difficulty of such decision-making is obvious, of which more in the following chapters. However, two reasons could be offered at this stage. First, the capital investment decision has a very long term effect on the business. Decision made in respect of any problem in marketing or production may have its impact say for a few months or a few years, but the effect of capital investment decision spreading for a period of 20-25 years is not very uncommon. Secondly, a wrong action in respect of capital investment cannot be readily retraced, when the mistakes are found. The funds are far too sunk to be easily recovered. On the other hand, an unsuccssful marketing strategy or production policy may be changed without a great loss. If a factory has been already built or a plant or equipment has been installed, a decision of not to operate them may put the company in a precarious situation. It is because of this sunk nature of capital investment that the manufacturer may operate even at a loss.

There is yet another point. It is the problem of measuring the worth of the rival investment proposals. Unlike in the cases of other business decisions, the investment criterion is not easily defined when the "time element" materially enters into the picture. Indeed, in recent years, with the growing sophistication of the managerial process, long horizon of modern enterprises, theoreticians and field executives have been hard put to clearly formulate the criterion for appraising capital investment in business. The process has hardly reached any stage of finality. The Harvard Business Review, to mention one of the leading journals relative to business management, will be found to be the forum of an expanding debate on the methods of measuring the investment worth. In fine, even when the formulation of alternative courses of actions relative to decision-making is concerned, the area of capital investment in business should be viewed as unique.

The other factor in decision-making relative to capital investment is the "time element" involved, This, in turn, brings up the problem of uncertainty. In no other business decisions does "future" hence uncertainty relating thereto, enter so much as it does in capital investment. Each of the data affects uncertainty on which the decision must proceed. In other words, it is encountered at so many points in capital investment problems. This is why a few company executives have come up with the suggestion of dealing with the ranges of uncertainties, or more precisely, the ranges of probabilities of data affecting the outcome of different capital investment projects. In any case, in recent years there has developed the complex of techniques to deal with uncertainty in decision-making generally, and capital investment decision-making in particular.

What has just been said would provide perspective to, and justification of, the present study on capital investment decisions in business.

What facets or areas of the decision-making in capital investment would this study be concerned with? What, in other words, is the nature and scope of the study?

A fair-sized capital investment decision, in usual business situations, such as that of plant expansion, for example, is the resultant of a large number of factors or elements or variables, so to speak. Of them all, two stand out to be the foremost. One is the task of developing alternative or competing but feasible investment proposals and ranking them according to established criterion - for such ranking is prerequisite to final choice. In this respect, namely, posing alternatives open to choice, decision-making relative to capital investments may not appear to be distinctive. Indeed, one may quickly join issue that this is germane to decision-making per se, whether it is in business or elsewhere, and whether it relates to problem of capital or other problems in business, for that matter.

Such a view overlooks the complexities of the usual decisional situations in the area of capital investment. We mentioned earlier of the nature of the stream of expenditures relative to a capital project. Because of the long-term implications or "long-horizon" of such decisions, the number of variables are far too many in capital investment problems. What is even more, the elements of the "decision-mix" - or the key input factors, one large corporation executive describes them - are not easily or accurately acertained. In the following chapter the study briefly touches upon some of the "input elements" and the problem relative to their accuracies. Clearly, the problem of correctly formulating pertinent data for decision-making is one of the perineal problems of the top management in the field.

Scope of the Study

Now for the statement of the nature and scope of the study. Taking note of the two distinctive facets of the decision-making in capital investment, the study tries to define, explain, analyse, and appraise the major techniques used in (1) measuring the investment worth, and (2) coping with uncertainties in making decision on capital investment proposal or proposals. The objective is not merely to examine the techniques *per se* but also to demonstrate how they have come to be applied to develop new investment criterion - new in relation to the conventional ones - to help the decision-maker. In Chapter IV is studied the different measures of investment worth of capital projects. In Chapter V the methods of dealing with the uncertainty are explained and integrated into the methods of evaluation of capital projects. At the end of the chapter we, therefore, come up with nature and scope of the refined concepts of "pay-offs", "expected monetary value" and "expected utility value".

Limitations of the Study

A few words about the limitation of the study. While the study does take account of the varieties of the capital investments in business - and this done in chapter II - it makes no attempts to demostrate the application of the different techniques in relation to any specific types of investments such as equipment replacement, plant expansion, research and development, new product development etc. To have made any such attempt would have unduly enlarged the scope of the study. It may, however, be mentioned that the techniques discussed in chapters IV and V would be generally applicable to capital projects such as expansion of plant facilities, equipment replacement and others which are mainly tangible in nature.

This brings us to briefly mention the other limitations: it is that the intangible capital outlays, such as those for research and development, many welfare types, market development etc., are not within the scope of the study. The major difficulty with these types of outlay is one of even developing any workable concreteness of the various factors relating to them. This generally is the case would be evident from the fact that in practice many of these types of capital outlays are provided for on ad hoc basis, and by large charge against current incomes rather than capitalized, at least so in accounting sense. On these types of capital expenses, and the specific types of capital expenditures that may be subjected to formal analysis will be clearly explained in the next chapter.

To sum up: keeping in mind tangible types of long-term capital investment, rather than those of working capital types, the author concentrates on studying:

1. the available quantitive techniques to measure the investment worth of capital investment projects; and
2. the major quantitive techniques that can cope with uncertainty that no capital investment project must overlook.

Providing perspectives to the main focus of the study, it draws a general profile of capital investments found in typical business enterprises and explain the factors, including the problems therein, that bear upon the decision-making in the area.

CHAPTER II

:A PROFILE OF CAPITAL INVESTMENT

Introduction

Capital, as the economists have defined it, are the "instruments of production" and "goods in process" - the stock of produced means of production that help to produce the flow of the income of the society. From the standpoint of an enterprise, capital investment would accordingly comprise of the totality of the assets that help to produce the flow of business activity of the enterprise. Thus defined, the stock of various kinds of assets found in the balance-sheet of the firm would constitute the totality of the capital investment of the enterprise. Indeed, the balance-sheet of the firms is but the profile of capital investment of a business unit, showing the total capital investments - the details of tangible and intangible categories and their dollar magnitudes. It is also clear that changes in the make up of the balance-sheet would reflect changes in the profile.

Evidently, a glance at the balance-sheet of an enterprise would readily reveal that capital investments in business do not constitute a homogenous entity. On the contrary, one is struck by the heterogeniety of the capital items that typical business requires to carry on its operations.

At the outset of the study,it, therefore, becomes necessary to ask: what is the nature and role of capital investment generally? What about the nature and functions of the different types of capital investment? What implications do they hold for decision-making in capital investment?

Nature and Role of Capital in Business

What are the features of capital investment? Three basic features of the capital investment may be mentioned here: (1) their enduring nature; (2) their usage through time helping to produce the flow of goods and services; and (3) their recovering the dollars sunk on their account in small doses spread over a period of time. Whether it is raw materials or finished goods inventory or plant or equipment or even such intangibles as goodwill and large research and development expenditures - whatever the category, these three attributes inhere in all of them. But the extent and degree of these attributes are not the same for all different categories. For example, raw material contributes to the flow of goods and services by being fully used up and recovered in the course of the turnover of the business, and hence in a very short period of time. The reverse would be the case of the plant and equipment - only a small part of it is being used up and recovered in the very same period, requiring the full recovery of the investment to be spread over a very long time.

Types of Invested Capital and their Roles

The business classifies its totality of capital investments into two broad categories: fixed and working capital. Representing cash, receivables and inventories, working capital contributes to the flow of goods and services by their full usage - losing their identity through working over whence the concept of the "turnover" and the terminology. On the other hand, representing "the instruments of production", such as plant and equipment, land and buildings etc., fixed capital contributes to the flow of goods and services only through usage in small doses. Accordingly, they play their role over a much longer period of time and dollar commitments in them are recovered in the same manner. In other words, they depreciate in value as they are used. As for their enduring nature, what is important to note is that they are fixed not so much because they are fixed in position as because their physical form does not change significantly in the course of their service. Apart from minor changes, between the time of their creation and the dramatic moment of their dissolution, their physical forms remain unchanged. The invested working capital circulate from one form to another in the process of business operation. It is because of such complete transformation of forms that they make up the cost of production by their full value at each turn of the cycle. Their functional role is thus entirely different from that of the invested fixed capital, which contributes to the cost of operation only for their usage, which is not exhausted all atonce.

This dichotomy of capital investment in business is writ large in managerial thinking and practice. This is clearly found in the published balance-sheets of companies. The assets side of it invariably show a clear cut division into the fixed and current assets.

In practice, the business world takes account of yet another type of invested capital. Goodwill, patents, copyrights, large capitalized expenditures for research and product development and outlays for market development are some of the examples for this category. Though placed along with other types of fixed capital in the balance-sheet, they are obviously different from them both in nature and function. They are intangible in form and very largely represented expenditures whose contribution to the flow of the business's activity cannot be measured as correctly as those of the others in fixed capital category, such as plant and equipment. Indeed, there is a larger measure of judgement in estimating their contribution to the flow of business activity as compared to the usage estimates of plant and equipment in a given period. There is also generally considerable irregularity in the contribution of the former than of the latter. Yet of their capital nature, the business executive has no doubt in his mind - regardless of how he might treat the dollars involved in his books,

Such then are the types and role of the different capital investments in business. But what implications do they hold for our study?

Capital Investments - Further Reflections

What are the implications of the conventional classification of invested capital in business from the point of view of this study? From the point of view of decision-making they are not fully comparable. For example, the time horizon on what is included in fixed investments is by far larger than in the case of investments in working capital assets. The recovery of dollars sunk in fixed investments is generally measured in years, while the recovery of fund locked up in inventories is at best measured in weeks or months, but always in less than a year. Indeed, in a deeper sense, especially from the point of view of decision-making on a "long horizon" - the perspective of this study - capital investment may be more narrowly defined. This may be done following the approach by Joel Dean. We quote:

> A capital expenditure should be defined in terms of economic behavior, rather than in terms of accounting conventions or tax law. The criterion, then, is the flexibility of commitment involved, that is, the rate of turnover into cash. For instance, inventories and receivables, although assets on the balance-sheet, turn over fast enough to make their level fairly adjustable to short-run changes in outlook. They are, therefore, excluded from the capital budget. Major replacement or additions to plant capacity, on the other hand, take several years to return their cash outlay. Their value to the

company during this period is us-ually much above the amount they could be sold for - that is they tie up capital inflexibility for long periods. They involve more uncertainty, forecasting, judgement and company wide thinking than an inventory investment does, and justify a special procedure for management review. The same is largely true for major research on new products and methods and for advertising that has cummulative effects. It applies as well to costs of educating executives and developing dependable distribution connections.

Obviously, our definition (of) capital expenditures does not correspond well to the accounting distinction between capitalized and expensed outlays. Although we include most items capitalized by accountants, we also include some important expenditures that are usually expensed by accountants, such as long term advertising, training and research. The disparity hinges largely on the tangibility of an asset rather than its economic nature, and contrasts the need for controls and conventions in accounting with the economist's intellectual ilcense.[1]

Classification of Capital Investment: Purposiveness

The evaluation of capital investment opportunities partly depends on the purpose of the investment. The finally defined types of capital investments may be classified according to the purpose of a particular enterprise. According to Joel Dean the different capital investment projects may be classified in terms of their objectives as follows:

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[1]Joel Dean, "Managerial Economics" (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1961), p.p. 554-555.

1. Replacement investments
   (a) Like-for-like replacement
   (b) Obsolescence replacement
2. Expansion investment
3. Product investments
   (a) Product improvement investment
   (b) New product investment
4. Strategic investments
   (a) Risk-reducing investment
   (b) Welfare investment[2]

The two types of replacement investments are of the cost reduction type. Expenditures for like-to-like investments are designed to achieve cost savings in that the age of equipment would otherwise adversely effect the cost of its operation. Similarly, expenditures for obsolescence replacement are designed to reduce costs through technological improvements in the equipment. Expenditures in this class do not effect the quantity of production or sales of the firm but are intended to reduce or minimize the cost of producing the quantity. The company might adopt the philisophy of reducing cost

[2]Joel Dean, "Capital Budgeting" (New York: Columbia University Press, 1951), chaps. V-IX.

through making the enterprise more capital intensive or labor intensive and also to replace old equipment with new to reduce cost.

Expansion investments are designed to increase the capacity of existing facilities, without change in the nature of production. Included in this category would be the expenditures for new plant to increase production capacity and expenditures to stimulate demand like advertising etc.

Product development investment may take two forms: (a) that of merely improving the present product or (b) that of developing a new product. It is particularly true of product investments that capital expenditures may encompass for more then mere acquisition of fixed assets. It is here that research, engineering and special advertising costs are incurred.

Finally, there are strategic investments of either the risk reducing or welfare type. The former relate to such activities as industrial integration and pure research. The latter deals with developments in the field of employee safety and welfare, personnel relations and public relations.

Classification of Capital Investment: Profit View

From the profit or savings point of view capital investment may be classified as profit-maintaining and profit-adding investments. The distinction between the two is obvious. A great many investment proposals require replacement of existing facilities on the ground that the new facilities will retain existing profits that would be otherwise lost. These investments are justified not by an increase in profit of the company but rather than by the threat of reduced profits if they are not accepted. Ray I. Reul classifies some of the more frequently encountered types of investment proposals as follows:

Profit-maintaining

1. Replacement of existing facilities which will no longer function.
2. Improvement of existing facilities to circumvent competition.
3. Provision of new facilities which were accidently or intentionally omitted when the original facilities were installed but which have now become essential to the continuation of the existing activities.

Profit-adding

1. Provision of new facilities that will increase profit by providing new business or by expanding existing operations.
2. Provision of facilities that will improve product quality and permit higher prices and profit margins.
3. Provision of facilities that will reduce the cost of production and result in increased profit through larger profit margins or increased volume of sales.[3]

Comments on the Classification

How are these different classifications of capital investment related to one another? Relating first type of classification with the second, it may be observed that except for the strategic investment, all other investments are either profit-maintaining or profit-adding. The strategic investments are unique in themselves, because they do not fit in the profit objective - maximization of profits.- of the company. Their objective is strategic in the sense that the benefits spread over the enterprise as a whole and stretch into the distant future and are related to long-term capital goals. The

[3] Ray I. Reul, "Profitability Index for Investments," Harvard Business Review, (Vol. 35, No. 4, July-August, 1957), p, 119

indirect benefits flow from these types of investments is rather difficult or impossible to measure.

It may be further observed that in reality, there is no big difference in profit-maintaining and profit-adding investments. In fact, profit-maintaining investments may be also described as negative profit-adding in the sense that it adds the profits, which would be otherwise lost. This puts the two types of investments on similar footing for the purpose of their evaluation and selection among the alternative proposals.

Capital Investment in the Study

Evidently, invested capital in business may be viewed from different standpoints - functions they serve, the purpose they have in mind, the profit motive behind them and the time perspective governing them. However, classified, only when capital investments contemplate a "long horizon" does the decision-making in capital investment show its full dimension. This is why the study comprehends only fixed capital investment. One more point. In the fixed capital investment, what of the relatively intangibles such as research and advertising expenditures?

Generally, in practice they are determined by aggregating the estimated costs of several projects, that the business may consider necessary, but modified by its ability to finance them. The detailed costs of different projects cannot always be estimated with reasonable accuracy or certainty. This is inherent in the nature of scientific research. The research division has to be given considerable flexibility in the size of funds given to it and in spending them. As for the outcome, some parts of a total project may lead to no results or prove impracticable no sooner than undertaken. On the other hand, others may suddenly lead to a land of promise, sooner than expected.

Such being the nature of scientific research projects, the management often finds it more realistic to approach the task of decision a little differenly from the typical fixed capital investment decision problems. It is that of making lump-sum appropriation on the basis of the availability of earnings. According to one study of decision making of funds for research projects in business, 73.4 per cent of the companies studied were found to follow the principle of lump-sum appropriations for funds for their research division.[4]

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[4]Robert N. Anthony, "Management Controls in Industrial Research Organizations" (Boston: Division of Research, School of Business, Harvard Uni.), p. 104

In view of the fact that long-term intangible capital investments of the type under discussion are decided upon differently from those of the others in the fixed inventment category, it is felt that no further consideration need be given to them in the study.

In short, the perspective of this study are provided by the variety of long-term tangible fixed investment that business requires to produce the flow its production and services.

In closing the chapter, mention may be made that in a sample survey made by the author the tangible fixed assets in the ten larget corporations in America ranged from 32 per cent to 67 per cent.

CHAPTER III

FACTORS AND PROBLEMS IN CAPITAL INVESTMENT DECISION-MAKING

Practically all businesses continually make investments. This means they are often involved in a series of overlapping investments with different starting dates, lives and profitability. The focal point of decision-making is the evaluation of an investment opportunity in order to measure the future economic significance of a decision to be made now.

Having briefly observed the profile of capital investment in typical businesses, and having stated which of them are particularly germane to this study, it is now necessary to sort out the various factors involved in capital investing situations as also to indicate the problems that inhere in them.

Factors and Decisional Process

According to one author, the decision-making in capital investment generally has to deal with six different elements or entities:

1. Total amount to be invested;
2. When increments of investments are to be expended;
3. Total amount of "cash flow-back" during the entire life of the project;
4. When the "cash floe-back" are anticipated;
5. The time value of money;
6. A consistent plan of return of the original investment.

It is interesting to note here that McKinsey & Company, Incorporated considers the key input factors in capital investment decision-making to be as many as nine:

1. Market;
2. Selling prices;
3. Market growth rate;
4. Share of market (which results in physical sales volume);
5. Investment required;
6. Residual value of investment;
7. Operating costs;
8. Fixed costs;
9. Useful life of facilities.

The company, of course, is engaged in large capital expenditures and hence a more detailed approach. To facilitate decisional process, the company goes on to group them into three categories: (1) market analysis (2) investment cost analysis and (3) operating and fixed costs.

These then are the elements or factors that constitute the decision-mix in capital investment. With the help of the data of these categories, the decision-maker proceeds to formulate the profitability or an yield of an investment project - the criterion by which he proposes to evaluate the projects. When confronted with copetitive proposals he does this for every project. This is how the many variables in the different projects are reduced to a common measuring rod - be it the yield or rate of return or payoff or expected monetary value or expected utility value. It is only by reducing them to a common basis of appraisal does he rank them to reach his final decision.

What kind of problems arise in relation to these factors or elements? In practice, problem arises in making the estimates of outlay, cost, revenue, economic life etc., determining the acceptance criterion, measuring profitability, the problem of comparability and finally coping with the uncertainty. It is interesting to briefly indicate the nature of these problems.

Problem of Computing Capital Outlay:[1]

Generally, any fair sized investment project will

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[1] The author owes the substance of this subsection to Reul, op. cit.

involve expenditures of many kinds and over a period of time. Such for example, would be the case of plant expension. What is even more, funds would be expended on various kinds of items - from land, for which there is no depreciation to revolving funds to complete the project. Again, some of the projects under managerial consideration may require expenditures which had been long deffered. In all such complex situations, it becomes difficult in practice to compute the investment outlay with exactitude. This then is one problem - sensibily estimate the capital outlay. The point is not one of mere accounting import. On the contrary, it is obvious that how accurately we compute the investment outlay will determine how accurate is the expected yield on the project. This is so because it is by relating the earnings and outlay of the project that the rate of return is, finally, established.

Though business enterprises are always confronted with investment expenditures of varying magnitudes and types, in most industries, they would tend to come under four categories: land, facilities, working funds and future obligations. Since these expenditures differ in nature, amount of risk and tax handling, amongst other things, it is obvious that it becomes necessary to segregate them in making an anlysis and arriving at the amount of capital outlay for the entire project, phased annually as the project may demand.

What kind of analysis is required for this purpose? Firstly, funds expended in land must be capitalized, but no depreciation income tax credits are permitted. Secondly, facilities is generally a large complex. These include the cost of proposed building, machinery, tools, patents and so forth. They may be either capitalized or expended depending on the federal tax regulations applicable. If capitalized income tax credit must be calculated in accordance with legally permitted methods. If expensed, expenditures are generally handled as if they were capitalized but with 100 per cent depreciation credit allowable the year expensed. Thirdly, the working funds. A sizable sum of money is usually tied up for the duration of the project in carrying accounts receivable, inventory of raw and finished materials and so forth. These expentures are in the nature of a revolving fund and involve a minimum risk because they can be usually recovered on a fairly short notice. Also they have no overall tax impact. Finally, there are the future obligations. Many times a project will receive an unfair advantage in its evaluation or a "free ride" by the assumption of the utilization of the existing surplus land, facilities, or working funds at zero investment cost. The next project that comes along, which may be equally profitable in principle is then penalized by having charged against it the full cost of the same facilities merely because the surplus was committed to the earlier project.

In other cases, we may recognize the need for certain facilities, such as increased steam boiler capacity, but choose to get along by pushing existing equipment at a cost penalty untill the need for still more capacity allows us to install a unit of economic size. What we are actually doing here is postponing an investment we recognize as necessary. Our evaluations would certainly not be correct or objective if we ignored this type of obligation, yet including such expenditures when they are not actually going to be made does not seem realistic either.

How can the capital components of the expenditure streams be brought together to arrive at total capital investment outlay? The solution recommended by Reul for this problem is to specify that where facilities are to be provided from surpluses or where acquisition of the facilities is to be postponed, the full cost of these acquisitions shall be included in the evaluation as a future requirement but not charged until the the actual expenditures of these funds are anticipated. To guard against accidental or deliberate over optimism in postponement, it is further suggested that permissible assumption of deferment be limited to five years or one-third of the life of the project, whichever is lesser. In this way, such expenditures are included in the total investment specified but their impact as profitability is lessened. Ruel even recommends a standard form by way of a work-sheet for tabulating and summarising proposed investment expenditures.

Problem of Revenue, Cost, Economic Life etc.

The problem in a capital investment decision is accurate forecasting. Evidently, capital investment decision has to be based on a forecast of anticipated cost of developing the project and the revenues over the productive economic life of the project. The cost data would generally be based on engineering estimates, and the revenue data would require market analysis and direct and indirect benefits flowing from the project. Relatively speaking, the cost data may be estimated accurately but it is not easy to forecast the revenue data with equal degree of accuracy. Where the expenditure is designed to reduce the costs without effecting the gross revenue-producing ability of the firm, one way or the other, or where the revenue function is relatively stable and not particularly sensitive to moderate changes, e.g. change in electric power demand due to the replacement of machine, the forecasting problem is greatly simplified. But where new products lines are being added, new market invaded or the expansion of existing product is comtemplated, the forecasting problem is compounded by numerous uncertainty factors, many of which may be created by the firm's very act of aggression. Clearly, in the absence of accuracy in forecasting of cost, revenue and economic life of the facility, the decision arrived at may spell disaster.

Problem of Determining the Acceptance Criterion

Another problem confronted by the management is to determine the criterion for acceptance or rejection of the project. Its not only necessary that a given project must be profitable but also that it must satisfy the acceptance standard set by the management. All of the projects will presumably add to or maintain profits, but they must compete among themselves in view of the limited resources of the enterprise - obtained either through borrowing or retained earning or self-generated funds. In other words, the profitability of the proposal may warrant the acceptance of the project but the funds shortage may loom large. The management, therefore, has to set up the minimum profit standard for acceptance of a project. At the same time, there would be many investment proposals that must be accepted, even though they do not satisfy the return requirement, either because they are necessary or because the present profit or the very existence of the business may otherwise be threatened. On this point reference was made earlier of the business practice in making decision. In the following chapters, we will, therefore, have in mind only those projects which can be subjected to object standards of return of one kind or another, preparatory to actual decision-making. How the decision-making might proceed in regard to the former categories has been broadly touched upon in the Chapter II.

Problem of Profitability

Summing up many of the problems is obviously the issue of profitability. Profitability or measure of investment worth is necessary to rank different investment proposals. Simple as it may seem, the concept of profitability is not unequivocal. On the contrary, various executives, faced with the same set of investment possibilities, may use different concepts and arrive at dissimilar ranking of different projects. Of these different standards of profitability, more in the following chapter.

Again, there may be projects whose profitabilities, whatever the standard applied, are not easily established. For example, a cost reducing proposal, without directly or indirectly affecting the earnings of the enterprise, may raise problems of identifying the savings in cost vis-a-vis alternatives open to the decision-maker. The problems of make or buy offer cases of extreme complexity - hence of difficulty in finally accounting for expected profit attaching to a particular proposal. Mention may also be made of various investment projects, such as those of welfare type and even risk reducing types, whose contribution to the total earnings of the enterprise may prove to extremely difficult to quantify. Finally, there is the time dimension of profit accruing from a capital investment project, and the consequent problem of current versus future dollars. Indeed, the theory of profit in Economic Science and the problem of calculating profits in practice is one of the most difficult problems in the area of Economics and Business Administration. Difficult as the definition of profit in practice may prove to be, and much as it may be true that "investment proposals are rarely accepted by top management solely on the basis of profit calculation alone" no decision can be reached in complete ignorance of it. This is what Bierman and Smidt has to say about the relevance of profitability or measure of investment worth in capital investment decisions:

> Insofar as the executive making the final decision is intimately familiar with the proposals, aware of the risk involved, know the possible technical and operating problems that may be encountered, and realize the potential erosion of earnings resulting from competitive action or changing technology, this criticism may well be correct. However, in large organizations it is impossible for the top management officials, who must finally approve or dis approve the investment proposals, to be intimately familiar with

> details of each and every proposal presented to them. To the extent that this intimate knowledge is impossible or impractical, these executives must rely on the evaluations of the recommendations from their subordinates. In order to make reasonable choices in weighing alternative investments, it is increasingly necessary that various proposals be evaluated as nearly as possible on some uniform, comparable basis. In such circumstances, although the measure of economic worth of an investment should never be the sole factor considered in making the final decision, it may play an increasingly important part in the majority of investments under considerations by the firm.[2]

Problem of Comparability

The problem of comparability is inherent in decision-making. But the comparability arises if the present investment decisions would particularly effect the profitability of future investment proposals. A group of investment is said to be comparable (and mutually exclusive) if the profitability of subsequent investment possibilities will be the same, regardless of which investment is accepted or if all are rejected. Investment alternatives should be combined into groups that are both mutually exclusive and comparable before a final decision is made.

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[2]Harold Bierman, Jr. and Seymour Smidt, "The Capital Budgeting Decision" (New York: The Macmillan Company, 1966), p.p. 10-11.

For example, in installing a new plant, it may be big enough for present capacity or provision for extra capacity may be made. This is mutually exclusive and comparable proposals. However, it is not comparable if the company is presently considering to expand the plant in future. The present decision whether or not to provide for the extra capacity may effect the future cost of expansion. In the same way, in designing a plant the number of possible changes that may be desirable at some future date (such as remodeling, installation of new machinery etc.,) is very large, and the cost of each such possible change will depend upon the basic plant design presently adopted. In such circustances, to make an analysis of truly comparable investments would require consideration of an unduly large numbers of alternatives associated with the proposal.

Problem of Uncertainty

The capital decision becomes more complex due to inherent risk in the proposals. From the forecasting problem it is evident that rarely does the firm's executive have the complete and accurate information as to future sales, costs, and profits. They must estimate not only buyers' demand but also future materials, prices, wages and productivity. Such estimates are necessary if plans are to be made for future and if operations are to be carried in efficient and profitable manner. These estimates are based on certain assumptions that may or may not come to be true. Managers must, therefore, make the decisions in an environment of incomplete or imperfect knowledge. Of course, managements do take all this into consideration while making the decision by forming some mental vision but they cannot be verified in any quantitive manner. All the same decision on capital investment is a decision in a world of uncertainty. This inherent uncertainty introduces the risk factor into the complexity of decision.

A General Comment

A general comment on the problems of capital investment decision process may be in order. It is the top management which is generally the decision-maker for capital investment in a business. But for the data on which to proceed the top management has obviously to depend on the flow of infomation on sales, costs, revenue and such other vital data. As Donald H. Wood[3] explains, it is notorious how misinformation and baised

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[3]Donald H. Woods, "Improving Estimates that Involve Uncertainty," Harvard Business Review, (Vol.44, No,4, July-August, 1966).

information tend to flow up the organization line. He explains how and why biases and distortions take place in the upward communication of judgements about critical matters affecting sales estimates and capital investment. As he suggests that it may all be due to the fear on the part of those who provide the data that they might be held accountable if what is supplied is found to have been over estimates. In fact Wood goes further to say that the top management is keenly aware of the distortions and biased views just mentioned, and have developed some kind of formula to revise the crucial data so as to be able to handle the problems of capital investment realistically.

To sum up: clearly, if decision-making on investment projects should be arrived at with intelligence, the top management must not only be explicit about the nature of capital expenditure, efficient to apply this knowledge in the specifics of a given, not always too clear-cut, series of capital expenditures, and come up with a meaningful and objective estimate of the investment requirement in dollar terms; the management must also ensure that information flows up the line in a precise manner such that its worksheet shall not be unreal and rank, and, finally, he should be aware of very many problems involved and inaccuracies that may creep into the figures that he will have to work on, so as to reduce a set of competing capital investment proposals to a common denominator that would measure the individual investment worth.

It is to the techniques that would measure the investment worth of capital projects - measure of productivity of capital investment proposals in other words - that we turn now.

CHAPTER IV

MEASURING INVESTMENT WORTH

The theoreticians and the practicing businessmen have developed a wide variety of techniques to measure the investment worth of a particular capital investment project, and hence of rival projects to arrive at optimal decision-making. The objective in appraising the worthiness of capital investment projects is basically a comparison of earnings and the cost of project or projects. What differentiate them from one another are various other factors that they additionally take into account. In this chapter we propose to discuss four of the most commonly used techniques - payout period, book return on book investment, discounted cash flow method and the MAPI method. It is also the purpose of the chapter to understand their distinctive nature, scope and the limitations of their applicability and, finally, to make a comparative appraisal of these techniques.

PAYBACK PERIOD ANALYSIS

The businessman has always been concerned with capital recovery, especially when confronted with the risks of obsolescence and/or of failure of demand for the flow of goods and services that the capital investment is expected to produce through time.

The concept of capital recovery period can be simple or highly sophisticated. The simplified and the most frequently used approach is to divide the cost of the capital investment proposal - i.e. total outlay - by the gross earnings of the immediate years of operation of the project. The most sophisticated approach takes into account other factors. According to George Terborgh, the exponent of the most sophisticated method, four variables enter into its computations: cost of the investment, the inferiority gradient or the lowering of the operational excellence of the equipment or project through time, the rate of interest and the correct service life of the capital equipment or project. Taking these factors into account, Terborgh[1] offers the following formula:

[1]George Terborgh, "Dynamic Equipment Policy" (New York: McGraw-Hill Book Company, Inc., 1949), p.p. 282-283

$$p = \frac{in + \frac{1}{(1 + i)} - 1}{i^2 n}$$

Where:

P= Payback period

i = Interest rate in decimals

n = Current service life

It should be mentioned that the formula reduces the variables to their present worth, and as such allows for varying future earnings of the project. This is done by the process of integral calculus.

Payback Period: General Nature

Payback period, also known as payoff period or capital recovery period, is probably the most widely used quantitative measure of investment worth. It measures the number of years required for the gross earnings on the projects (i.e. with no allowance for capital depreciation or wastage) to payback the original outlay. It should be mentioned that the payout period may be either actual or average. In the first case, the method is to add up projected annual earnings untill the sum equals the outlay on the project. In the second case, the annual earnings over the life of the project is averaged and the annual average earning is divided into the outlay to arrive at the payout period. How these two computations may lead to different results will be seen in the exhibit 4.2. In practice, however, the management relies more often on the actual payout period.

The payback period, thus basically ia a time concept and not a rate concept. It measures the speed of recovery of the total outlay to the exclusion of all other considerations. Where the capital investment outlay is not at all once but a phased activity, what the payout compares is the incremental cash investment in the project with the yearly incremental throw off of cash (after taxes, but before depreciation) attributable to the project. In practice, the technique ignores the economic or physical life of the investment project as also the earnings following the recovery period.

Simple in concept, and readily applied the payout criterion may prove helpful in comparing simple rival projects. Alternatively, rival complex projects might also be decided upon on the basis of shortest payout period, provided they offer the same rate of return. This is because the uniform rate of return of different projects irons out the many variables attached to each of them - earnings, economic life and capital outlay. Payback may be also useful to select from amongst high profitable proposals, which because of their established high rate of return, though not identical, do not require the use of refined rate of return. In such a situation, the payback period may provide a handy and easily handled criterion for decision-making. Finally, the payback may be preferred as useful by the companies whose investment criterion has to be, in view of their situation, liquidity more than profitability. Calculated on actual rather than on average basis, the payback has some value as a measurement of one aspect of risk of capital investment. Remembering that such investments are characterized by futurity, payback measures how long the risk of the investment will continue in the dynamics of the situation.

Payback Period: Scope and Limitations

Of the different situations where the payback period approach in capital expenditure management may prove extremely relevant, Joel Dean has the following to say:

> Payback can serve as a coarse screen to pick out high-profit projects that are so clearly desirable as to require no refined rate of return estimates and to reject quickly those projects which show such poor promise that they do not merit through economic analysis. In addition, it may be adequate as a measure of investment worth for companies with a high outside cost of capital and severly limited internal cash generating ability in comparison with the volume of highly profitable internal investment opportunities. If a shortage of funds forces the company to accept only proposals which promise a payback period after taxes of two years or less, the use of a more refined measure might not affect the list of accepted projects.
>
> It also can be useful for appraising risky investments where the rate of capital wastage is particularly hard to predict. Since payback weights near year earnings heavily and distant earnings not at all, it contains a sort of built-in hedge against the possibility of a short economic life.[2]

In other words, he contemplates three types of real life investment situations. Firstly, since payback is based on gross earnings of the near years, it is a rough and ready approach. Secondly, there are specific situations of investing company which make the approach very well justified. Finally, there is the situation of overly risky venture that the economic life or the distant earnings of the investment project must necessarily be inexact.

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[2]Joel Dean, "Measuring the Productivity of Capital," Harvard Business Review, (Vol.32, No.1, January-February, 1954), p.p.123-124.

We have said above that the payback has some value as a measurement of one form of risk. Robert H. Baldwin analyses the payback from the point of view of risk in capital investments:

> A better measure for reflecting the risk is the payback period. It has the important feature of showing how long the company's money is going to be at stake even though it does not represent management's judgement of the proposals chances of performing as estimated. It is an index which can be consistently derived by various people in accordance with the figures involved. Insofar as it is reasonable to expect that the longer the time before an original investment is recovered, the greater the risk of recovery, the payback period is a valid measure of a measure eliment of risk.[3]

However, for the vast majority of capital investment situations, payback is not an adequate technique for measuring the investment worth. Its most obvious defect is that it does not measure profitability, at least not as accurately as such projects ordinarily would call for. In other words it ignores what happens after a project has returned its investment. The point will be made clear.

Let us an investment of $20,000 earns an annual savings of $5,000. If the economic life of the investment is 6 years, the return would be 8% per annum. But

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[3]Robert H. Baldwin, "How to Assess Investment Proposals," Harvard Business Review, (Vol.37, No.3, May-June, 1959), p.102.

supposing its life to be 5 years, the return is 5%, and if the life is just four years, the return is nil. Judging the same investment from the point of view of payback, it is clear that it fails to provide an adequate means of discriminating among new investment opportunities. Variables in the life of the project are left out of count by the payback method.

Let us change the investment problem a little differently. Suppose, there are three investment projects each involving an outlay of $125,000 and the life of the projects are 10, 15 and 25 years respectively. The annual income generated by the investments begin at $25,000 and then declines in later years in each cash as shown in exhibit 4.1. Since the annual incomes are identical in the early years, each project has the same payout period; namely, five years. By this standard of measurement, therefore, the projects would be equal from an investment standpoint. But actually the return on investment ranges from 12% per year for project A, which has the shortest life, to 20% per year for project C, which has the longest life.[4]

To sum up: Firstly, the conventional payback

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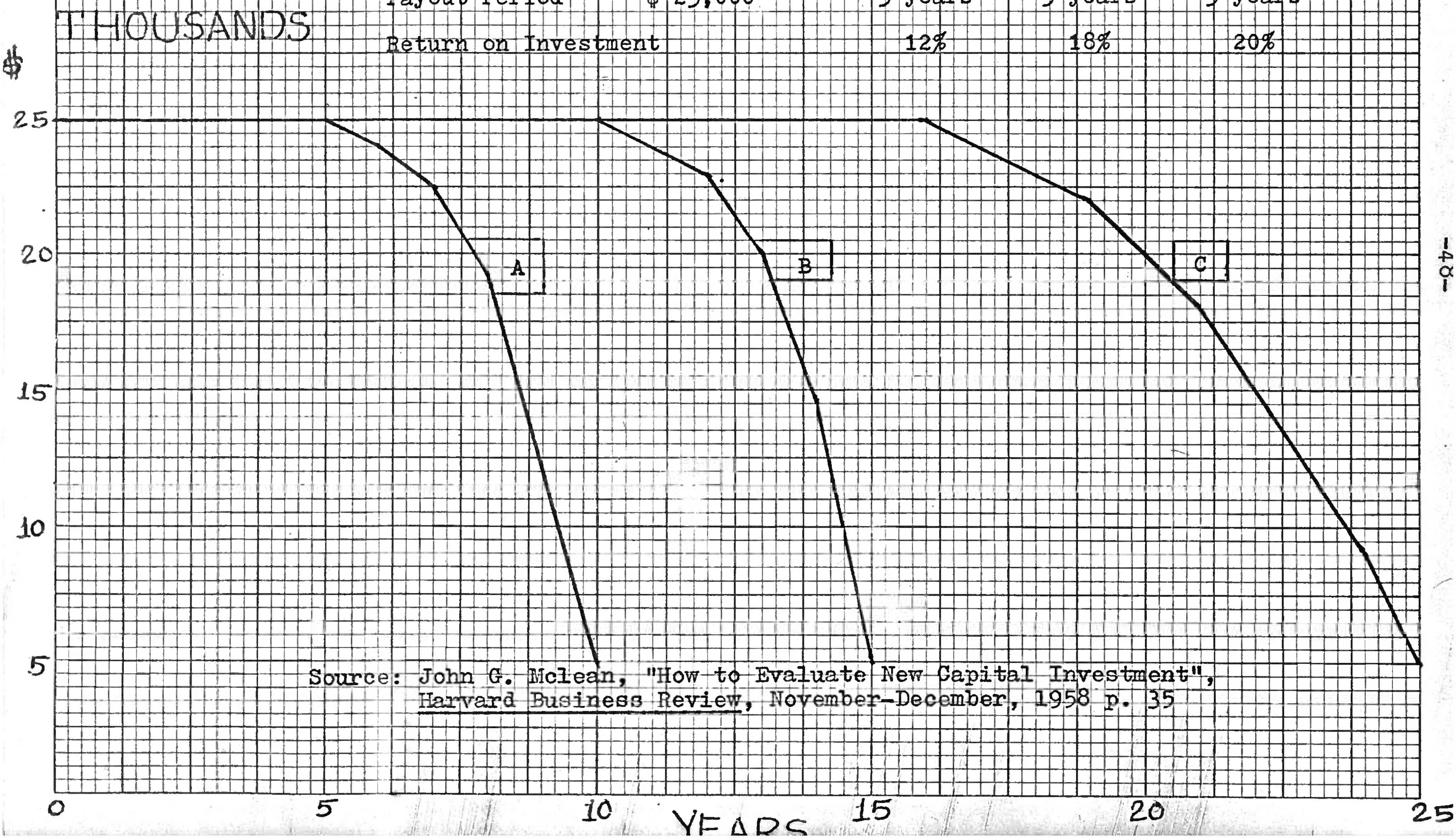
[4]John G. McLean, "How to Evaluate New Capital Investments," Harvard Business Review, (Vol.36, NO.6, November-December, 1958), p.63.

EXHIBIT 4.1

	Project A	Project B	Project C
Original Investment	\$125,000	\$125,000	\$125,000
Life of Investment	10 years	15 years	25 years
Payout Period $\frac{\$125,000}{\$25,000}$	5 years	5 years	5 years
Return on Investment	12%	18%	20%



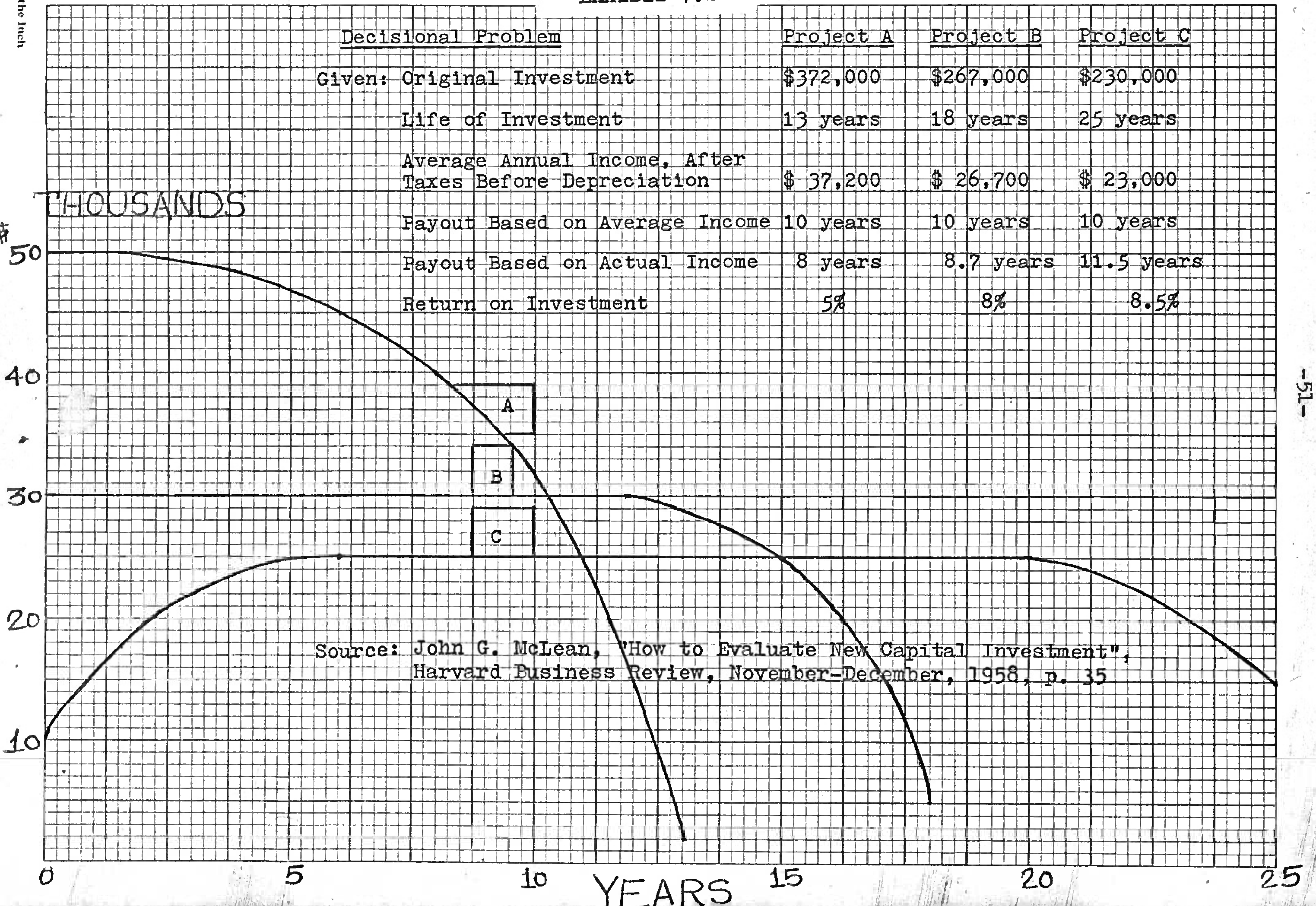
Source: John G. Mclean, "How to Evaluate New Capital Investment", Harvard Business Review, November-December, 1958 p. 35

method, even where it may be usefully employed, is deficient because it does not take into account the full dimension of the time element of the investment - more specifically, the service life of the project; nor does it take account of the obsolescence factor or what has been called the "inferiority gradient" and the related rate of interests. Secondly, in the nature of things, while one can compare payback periods of different projects in an objective manner, it is different when only one project is under consideration. For unlike a market interest rate to provide an objective standard, there is nothing comparable to it in payback method. In other words, to screen a particular investment by this method, the management has to arbitrarily decide on what it considers as acceptable. Finally, for evaluation of investment worth of a project it's necessary not only to consider the payback period but also the size and duration of the returns expected beyond this period. In fact, if the after payback duration of a project is long, the reciprocal of the payback becomes a good approximation of true profitability. If the post payback period is zero, the true rate of return is also zero, and the project is worthless no matter how short the payback period is. For sound evaluation of the project the two dimensions - payback period and post-payback duration - must be integrated into a single judgement. If this is done, the original concept of payback period vanishes and we are left with one variant or another of a computed rate of return.

Looking at the data and the exhibit one might conclude that all one has to do to arrive at a decision is to look at both the payback periods and the economic lives of the projects under consideration and when payout period is same for all the different projects, as in the above example, the choice is obvious. The choice is in the favor of the one with the longest economic life. When payout periods are different but the economic life is same the decision would be still easier. But usually the executives are confronted with capital investment projects wherein payout periods and economic life do not come in such convenient combination. Under such circumstances the simlisite approach would obviously be of no avail. Let us take a more realistic capital investment decisional problem as shown in the exhibit 4.2. The payout periods here ranges from 8 years in case of project A, which has a high initial income and a short life, to 11.5 years in the case of project C,

EXHIBIT 4.2

Decisional Problem	Project A	Project B	Project C
Given: Original Investment	$372,000	$267,000	$230,000
Life of Investment	13 years	18 years	25 years
Average Annual Income, After Taxes Before Depreciation	$ 37,200	$ 26,700	$ 23,000
Payout Based on Average Income	10 years	10 years	10 years
Payout Based on Actual Income	8 years	8.7 years	11.5 years
Return on Investment	5%	8%	8.5%



Source: John G. McLean, "How to Evaluate New Capital Investment", Harvard Business Review, November-December, 1958, p. 35

which has a low initial income and a long life. On the basis of the payout periods, therefore, Project A would appear to be the best of the three. Actually, however, the true rates of return on investment ranges from 5% for project A to 8.5% for project C. The order of the desirability indicated by payout periods is thus exactly the reverse of that indicated by return-on-investment figures.[5] Clearly, the facets of decision-making on capital investment are too complicated to be handled by any such method as the payback alone. As the illustrations show, payback approach does not help us to rank the investment projects in order of desirability.

Apart from the failure of the payback analysis to measure the profitability, it tends to overweight the importance of liquidity as goal of capital expenditure program. Of course, no firm can ignore the needed liquidity, but profits cannot be sacrificed at the cost of liquidity. By confining analysis to the proposals gross earnings (before depreciation), the payback, as already mentioned, fails to consider the probable economic life of the project. Also it gives no consideration to the time value of money, of which more later.

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[5] McLean, <u>Ibid</u>.

Payback Period in Practice:

How is the payback method being used by the Industry? It is very widely used in the industry when replacements of equipment and/or short period payoff for any capital investment is under consideration. As George Terborgh points out "There can be no doubt that when the analysis goes beyond mere intuition and relies on some test of replaceability, the test is likely to be the recovery of the investment over a specified pay-off period".[6] As he points out, payoff method is unquestionably the king of all practical short cuts.

What kind of payoff does businesses usually expect in practice? There is no statistical evidence on this point. A few surveys indicate short payoff period, and that this period is often only a small fraction of the normal service life of the capital investment. Apart from the payoff period in relation to the service life of the capital project, the payoff period required by the industry, according to one survey, typically ranged from 1.5 to 5 years.[7]

In concluding the study of the technique, it

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[6]Terborgh, op. cit., p.189

[7]Ibid, p.p. 189-94.

may be observed that because payback does not measure or reflect all the dimensions of profitability which are relevant to capital expenditure decisions, it is neither exclusive enough nor sensitive enough to be used as the company's over all measure of investment worth.

BOOK RETURN ON BOOK INVESTMENT:

Before proceeding to study the second technique- book rate of return - it is well to make clear the concept of rate of return per se and the variables that go into its computation. Unlike in the case of payoff method, the rate of return takes account of (a) the total earnings or savings from the capital investment over its entire life and (b) the earnings as net of depreciation or recovery of the investment outlay. Rate of return thus comprehends more variables than the payoff calculation.

Since the rate of return takes account of the full life time of the capital expenditure project, better and more comprehensive standard of acceptance or rejection is brought to bear on the alternative proposals. Projects can be arranged in a ladder of priority even though they may have same payback period. In other words, the diversity of characterstics of the projects does not impede their comparison with one another. Investment for new product development can be compared with the cost reducing projects of existing products on the basis of their promise of return. The rate of return also provides a realistic comparison with the cost of capital. In as much as the cost of capital, which is an externally determined measure, and as any capital investment should earn at least as much as the cost of capital, the latter provides the minimum acceptable profitability standard for investment proposals. For example, if the cost of capital to a company is 10%, any investment project promising less than 10% return must be rejected without making further analysis.

Though simple in principle, there are problems in combining its determinants - investment, income and the economic life - in an index of profitability or rate of return, of which a little later.

Known by such different names as accounting method, an average book method, level book rate of return method, or simply as return on investment, book return on book investment deals with book value - the outlay on investment and the earnings as estimated at the project stage. The earnings total is expressed as a percentage of outlay to give the rate of return. However, the method of computation and the form of presentation often varies in practice. For example, the return may be expressed as <u>per dollar of outlay</u> or as <u>average annual return per dollar of outlay</u>. In the second case total earnings are first divided by the number of years during which they are received, and this figure (the average return per year) is then divided by the original outlay required by the investment. Again, there is the return on <u>original investment</u>, when average annual income from a project (after taxes and depreciation) is divided by the total original capital outlay and is expressed as a percentage. Finally, we may have the return on <u>average investment</u>. Here the average annual income (after taxes and depreciation) is divided by <u>half</u> the original investment or whatever figure represents the mid-point between the original cost and the salvage value or residual land value in the investment. The reason for this approach is to make allowance that the original outlay is not the same throughout the life of the capital investment. In other words, that the outlay is also being recovered at the same time that the capital assets are yielding income is given simultaneous recognition. In this respect, the other computations are inferior.

It would be evident that ranking of rival investment projects would be different for different methods of computation. The point has been clearly illustrated by Bierman and Smidt.[8] This happens because different computations use different figures for numerators and denominators required to arrive at the ratio.

Indeed one of the shortcomings of the method under consideration is that it is an altogether an ambiguous concept, particularly with respect to the computation of the denominator of the ratio. Hence the different rates of return for the same proposal. As is clear from the above, sometimes, original book investment is used, sometimes, average book investment and sometimes, even a weighted average of period by period book investment. The concept of earnings is

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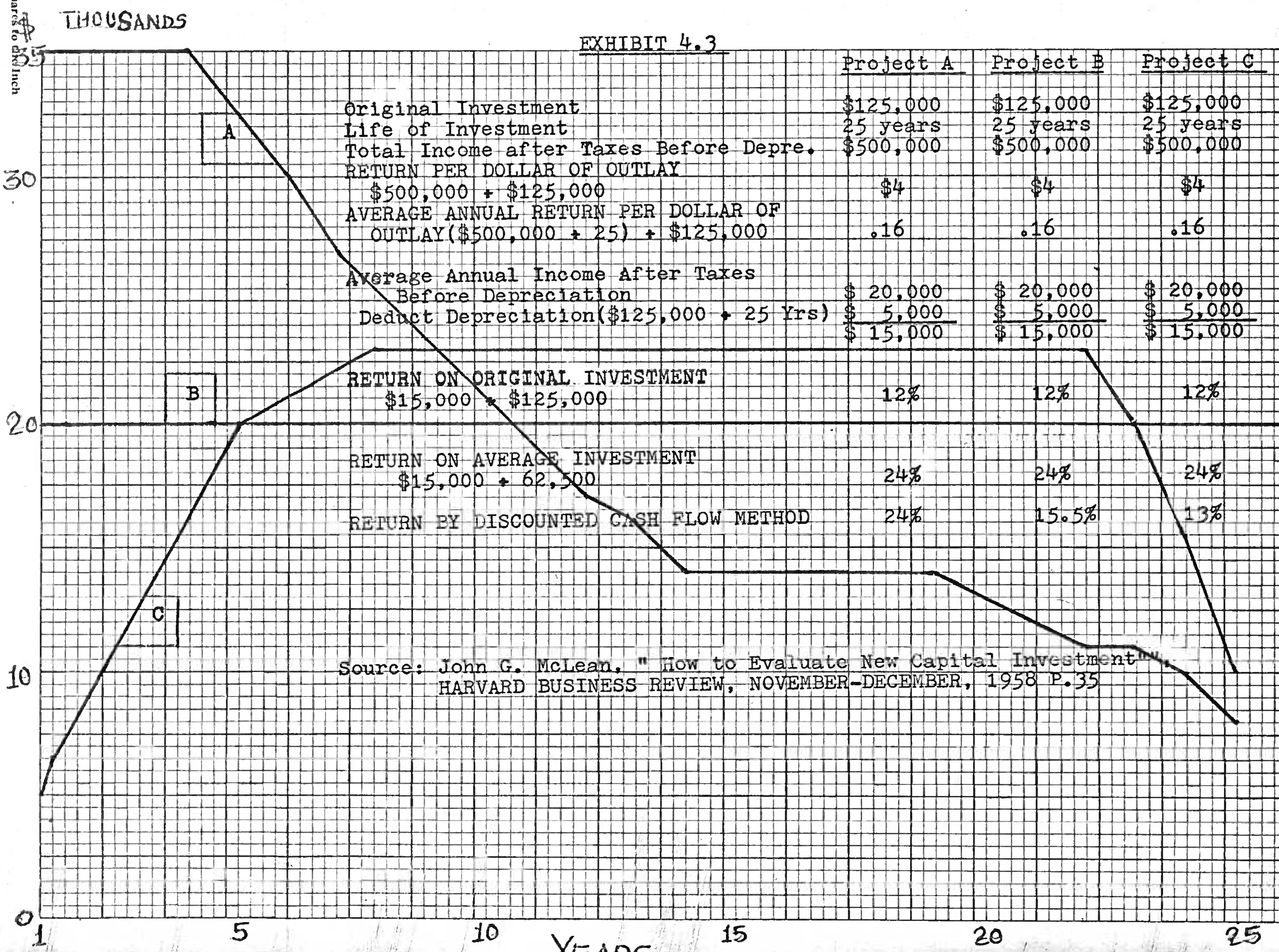
[8] Bierman and Smidt, op. cit., p.31

also not clear. Earnings can be either gross or net of depreciation. They can be average for several years or for the first year only. These varieties of alternative methods produces a range of rates of return as may be seen from exhibit 4.3 where data on three projects are compared.

Apart from ambiguities involved, the method fails to take into account the "timing" of expected earnings or of expected outlays. The economic worth of an investment will obviously be affected by the <u>time shape</u> of its life time earnings, because near money has greater economic value than distant money (more about this later). Failure to reflect these time shape disparities in the index of profitability leads to less than optimal expenditure decisions. The point may be elucidated by returning to the exhibit 4.3, setting out the data on three different projects. In our illustration we have obtained the rate of return by using the arithmatic average; (a) dividing the total income by the length of time, giving an annual average income; and then (b) dividing this annual income first by the original investment and next by the average investment to arrive at the identical rates

EXHIBIT 4.3



	Project A	Project B	Project C
Original Investment	$125,000	$125,000	$125,000
Life of Investment	25 years	25 years	25 years
Total Income after Taxes Before Depre.	$500,000	$500,000	$500,000
RETURN PER DOLLAR OF OUTLAY $500,000 ÷ $125,000	$4	$4	$4
AVERAGE ANNUAL RETURN PER DOLLAR OF OUTLAY($500,000 ÷ 25) ÷ $125,000	.16	.16	.16
Average Annual Income After Taxes Before Depreciation	$ 20,000	$ 20,000	$ 20,000
Deduct Depreciation($125,000 ÷ 25 Yrs)	$ 5,000	$ 5,000	$ 5,000
	$ 15,000	$ 15,000	$ 15,000
RETURN ON ORIGINAL INVESTMENT $15,000 ÷ $125,000	12%	12%	12%
RETURN ON AVERAGE INVESTMENT $15,000 ÷ 62,500	24%	24%	24%
RETURN BY DISCOUNTED CASH FLOW METHOD	24%	15.5%	13%

Source: John G. McLean, " How to Evaluate New Capital Investment",
HARVARD BUSINESS REVIEW, NOVEMBER-DECEMBER, 1958 P.35

of return in each case for the three projects. Here we see that each project has the same rate of return - 12% in case of return on original investment and 24% in case of average investment. But are all the three projects of equal value to the investor? Is not project A lot more preferable than project C? Would not the value of project B lie somewhere between project A and C? The computations do not recognize the importance of early income compared to later income, as may be seen from the time path of earnings of different projects. The decision-maker is in dilemma - how does he choose from amongst the alternatives. Here is the limitation of the method under discussion - it ignores time dimension or futurity of capital investment - the unique characterstic of capital outlay.

Let not the reader, looking at the exhibit 4.3, feel that the illustration is hypothetical. Project A's income flow would characterise the mining industry. Project C is typical of manufacturing industries whose product go through a life circle. Project B would approximate to utilities with regulated earnings, or replacement of machinery.

To sum up: The method bristles with ambiguities; It fails to take into account the timing of expected earnings or expected outlays. It dees its job only under fairly specific conditions relating to the investment - outlay occuring at a single point of time and expected earnings flow evenly over the life of the project. Unless these conditions govern the situation the book return on investment method and its varients would yield results that are subject to fairly wide errors.

DISCOUNTED CASH FLOW METHOD

The future dollars are not the same as current dollars. In capital investment we are involved in future. The income stream of the investment of today spreads far into the future. The investment outlay itself may spread over years. Accordingly, the method we have discussed suffers from one defect - it compares earning dollars of the future with the outlay dollars of today. The method, we shall now discuss, takes note of the point and offer another alternative of measuring the investment worth.

Before we turn to the discounted cash flow technique of measuring the investment worth, it is necessary to introduce and explain the concept of the present or discounted value of the future sum, since this concept is basic to discounted cash flow technique.

The present value of $100 one year hence can be defined as the quantity of money invested today at a rate of interest to yield $100 at the end of the year. Suppose an investment at 6 per cent interest rate promise to return a total of $100 at the end of the year. Since $1.00 invested today at 6 per cent would grow to $1.06 at the end of one year, we can find the present value of $100 in one year by dividing $100 by $1.06. This gives us $94.34 as the present value of $100 one year hence. In other words, the discounted value of $100 one year hence is $94.34. By repeated application of this method, present or discounted value of future sums can be found in complicated situations, taking into the principles of compound interest or annuity as the case may be. Since tables are available that give the appropriate conversion factors for various periods and rate of interest the calculations involved are relatively simple.

Nature and Scope of Discounted Cash Flow Method

What is the nature and scope of discounted cash flow method? The discounted cash flow is but another method of computing rate of return on investment - but explicitly taking into account the time path of cash outlays on and receipts from capital investment. Under the discounted cash flow approach, the rate of return is the rate which makes the expected cash inflow from a new investment equal to the principal of the investment when the investment is made at a single point in time. When the investment outlay is not made at a single point in time but is expected gradually, both the cash outflow and cash inflow are discounted to a common point in time. In other words, the mechanics of this technique essentially requires the determination of a rate at which the incremental cash benefits (after taxes, but before depreciation) expected from a project have a discounted present value which is exactly equal to the discounted present value of the phased outlays required for the project's implementation. It is the true rate of return at which an investment is repaid by proceeds from a project. Such a rate of return can be found by trial and error, using different rates of interest for discounting the cash outlays and cash proceeds at a single point in time.

How to Calculate the Rate of Return

For calculating the rate of return, the first step in the discounted cash flow technique is to prepare a year by year schedule of cash returns (inflow) expected from a project. This cash flow is the additional amount of cash received as a result of making the investment as compared to not making the investment. The cash inflow consists of (a) the net income from the investment after taxes, plus (b) the annual depreciation charges. Depreciation is a so called "non-cash" cost involving a charge against income and is a deduction for tax purposes. This emphasizes the importance of depreciation. Whether cash is returned to the enterprise through increased earnings or through depreciation, its still a return of funds.

Similarly, a year by year schedule of cash outlay on investment is prepared. This schedule is necessary only in case the outlay is not at a single point of time. Care must be taken not to schedule as investment those renewals or other expenditures of the project which are revenue expenditures. In this connection, it may be added that the start up costs incident to getting the project under way, like training of a work force etc, are frequently capitalized and made part of the capital investment.

Once the year by year cash inflow and cash outlay data have been assembled, the computation may be done through trial and error. We can start with any rate of interest and find for that rate the present value of the cash proceeds and the present value of cash outlays. If the present value of cash proceeds exceed the present value of outlay, then some higher rate of interest may be taken and present value for that rate may be calculated. By repetitive trial a correct rate of interest may be which equates or nearly equates the both present worths. This is the most sophisticated or true rate of return. This clearly is the internal rate as distinct from the market interest rate.[9]

Table 4.1 illustrates the way in which rate of return can be determined under the discounted cash

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[9] Also called internal rate of return, profitability index, investors method, interest rate of return.

TABLE 4.1

WORKSHEET FOR COMPUTATION OF THE
DISCOUNTED RATE OF RETURN

(Investment of $7,525 with anticipated life of 10 yrs.)

Year	Cash Flows	Present Value of Cash Flow at Various Rates of Discount					
		12%		15%		20%	
		DF	PV	DF	PV	DF	PV
1	1,500	0.893	1,339	0.870	1,305	0.833	1,249
2	1,500	0.797	1,195	0.756	1,134	0.694	1,041
3	1,500	0.712	1,068	0.657	985	0.579	868
4	1,500	0.635	952	0.572	858	0.482	723
5	1,500	0.567	850	0.497	745	0.402	603
6	1,500	0.507	760	0.432	648	0.335	502
7	1,500	0.452	678	0.376	564	0.279	418
8	1,500	0.404	606	0.327	490	0.233	349
9	1,500	0.361	541	0.284	426	0.194	291
10	1,500	0.322	483	0.247	370	0.161	241
	15,000		8,472		7,525		6,285

DF - Discount Factor

PV - Present Value

flow method. The investment contemplates a single point outlay of $7,525 and has an anticipated life of ten years. In this case, an approximate rate of 15% is found to make the present value of future earnings stream equal to the present cost of the investment. So this is the rate of return.

In the above, a single point investment was taken. Let us now take a more complex situation: phased capital outlay and cash inflow. How can the technique be applied now? Illustration data of this situation are given in Table 4.2. It will be noticed that the problem of computation is to find the present worth of the two flows at common point of time, in 1957/58 in the illustration - indicated by the thick horizontal line. In the illustration, as also in practice the common point of time is generally the peak of the phased investment outlay. By trial and error method we arrive at 15% at which the present worths of the outlays and receipts are almost equal. If we now increase the interest rate a little more say to 16½% and repeat the trial, we would arrive the equality between the two present worths. Alternatively, we may reach this rate through inter-

TABLE 4.2

COMPUTATION OF THE DISCOUNTED RATE OF RETURN

TIMING			TRIAL #1 0% INTEREST RATE	TRIAL #2 10% INTEREST RATE		TRIAL #3 15% INTEREST RATE		TRIAL #4 25% INTEREST RATE		TRIAL #5 40% INTEREST RATE	
	CAL. YEAR	PERIOD	ACTUAL AMOUNT OF DISBURSEMENTS	FACTOR	PRESENT WORTH	FACTOR	PRESENT WORTH	FACTOR	PRESENT WORTH	FACTOR	PRESENT WORTH
BEFORE ZERO POINT											
		3RD YR. AT ST.		1.350		1.568		2.117		3.320	
		3RD YR. DURING		1.265		1.456		1.673		2.736	
	56	2ND YR. AT ST.	$ 60,000	1.221	$ 73,300	1.350	$ 81,000	1.649	$ 98,000	2.225	$ 133,500
		2ND YR. DURING		1.162		1.253		1.459		1.634	
		1ST YR. AT ST.		1.105		1.162		1.264		1.492	
	57	1ST YR. DURING	$1,050,000	1.052	$1,104,600	1.079	$1,133,000	1.136	$1,192,800	1.230	$1,291,500
AFTER ZERO POINT											
	58	1ST YR. AT ST.		1.000		1.000		1.000		1.000	
		1ST YR. DURING	385,000	.952	366,500	.929	357,700	.885	340,700	.824	317,200
	59	2ND YEAR DURING	30,000	.861	25,800	.799	24,000	.669	20,700	.553	16,600
	60	3RD " "		.779		.686		.537		.370	
	61	4TH " "		.705		.592		.418		.248	
	62	5TH " "	48,000	.638	30,600	.510	24,500	.326	15,600	.166	8,000
		6TH " "		.577		.439		.254		.112	
		7TH " "		.522		.376		.197		.075	
		8TH " "		.473		.325		.154		.050	
		9TH " "		.428		.280		.120		.034	
		10TH " "		.387		.241		.093		.023	
TOTALS (A)			$1,573,000		$1,600,800		$1,620,200		$1,668,700		$1,766,800
	CAL. YEAR	PERIOD	ACTUAL AMOUNT OF RECEIPTS	FACTOR	PRESENT WORTH	FACTOR	PRESENT WORTH	FACTOR	PRESENT WORTH	FACTOR	PRESENT WORTH
	57	1st Yr. Before During	25,000	1.052	26,300	1.079	27,000	1.136	28,400	1.230	30,800
AFTER ZERO POINT	58	1ST YEAR DURING	168,400	.952	160,300	.929	156,400	.885	149,000	.824	138,800
	59	2ND " "	263,300	.861	226,700	.799	210,400	.689	181,400	.553	145,600
	60	3RD " "	257,200	.779	205,500	.688	177,000	.537	138,100	.370	95,200
	61	4TH " "	255,100	.705	179,800	.592	151,000	.418	106,600	.248	63,300
	62	5TH " "	252,700	.638	161,200	.510	128,900	.326	82,400	.166	41,900
	63	6TH " "	348,000	.577	200,800	.439	152,800	.254	88,400	.112	39,000
	64	7TH " "	343,700	.522	179,400	.378	129,900	.197	67,700	.075	25,800
	65	8TH " "	339,500	.473	160,600	.325	110,300	.154	52,300	.050	17,000
	66	9TH " "	334,800	.428	143,300	.280	93,700	.119	39,800	.034	11,400
	67	10TH " "	330,500	.387	127,900	.241	79,700	.093	30,700	.023	7,000
	68	11TH " "	326,300	.350	114,200	.207	67,500	.073	23,800	.015	4,900
	69	12TH " "	321,600	.317	101,900	.178	57,200	.057	18,300	.010	3,200
	70	13TH " "	317,300	.287	91,100	.154	48,900	.044	14,000	.007	2,200
	71	14TH " "	313,100	.259	81,100	.132	41,300	.034	10,600	.005	1,600
	72	15TH " "	308,300	.235	72,500	.114	35,100	.027	8,300	.003	900
	73	16TH " "	304,100	.212	64,500	.098	29,800	.021	6,400	.002	600
	74	17TH " "	303,800	.192	58,300	.084	25,500	.016	4,900	.001	300
	75	18TH " "	303,600	.174	52,800	.073	22,200	.013	3,900	.001	300
	76	19TH " "	303,200	.157	47,600	.062	18,800	.010	3,000	.001	300
	77	20TH " "	517,900	.142	73,500	.054	28,000	.008	4,100		
	78	21ST " "	2,900	.129	400	.046	100	.006			
	79	22ND " "	2,700	.117	300	.040		.005			
	80	23RD " "	2,500	.105	300	.034		.004			
	81	24TH " "	2,200	.095	200	.029		.003			
	82	25TH " "	2,000	.086	200	.025		.002			
	83	26TH " "	1,800	.078	100	.022		.002			
	84	27TH " "	1,700	.071		.019		.001			
	85	28TH " "	1,600	.064		.016		.001			
	86	29TH " "	1,500	.058		.014		.001			
	87	30TH " "	1,400	.052		.012		.001			
TOTALS (B)			6,257,700		2,530,800		1,791,500		1,062,100		630,100
RATIO A/B			.25		.63		.90		1.57		2.80

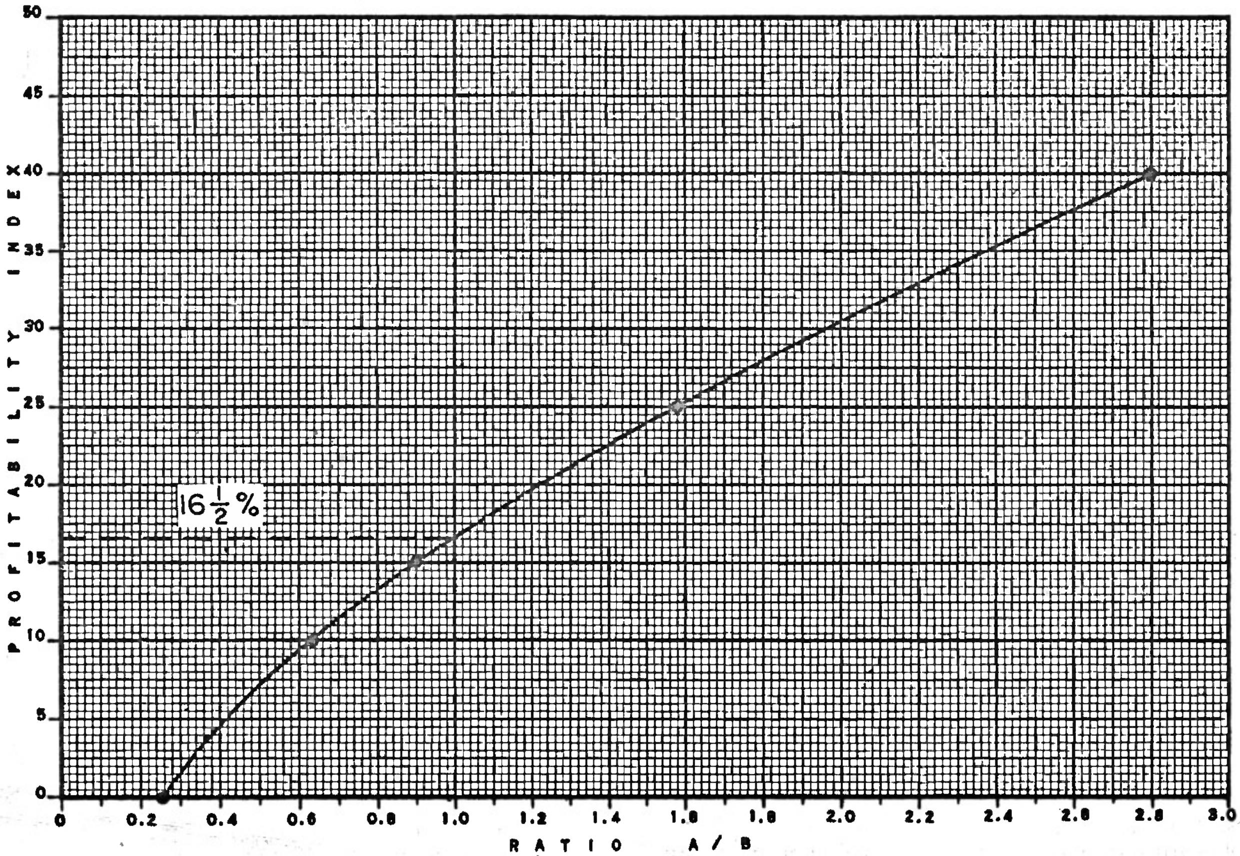
Source: Ray I. Reul, "Profitability Index for Investments", Harvard Business Review, July-August, 1957, p. 53

polation as shown in the exhibit 4.4.

Superiority of the Technique

Let us go back to our exhibit 4.3, showing three different projects all requiring the same original outlay, having the same economic life, and generating exactly the same total income after taxes and depreciation. The return on the original investment would be 12%, and the return on average investment is 24% in each case. By these standards, therefore, the projects would appear to be of equal merit and decision-making becomes difficult. In fact, the decision-maker has no criterion to go on with. However, closer examination of the projects show that Project A is by far the best of the three because it generates a larger share of its total income in early years of its life. The investor thus has his money in hand sooner and available for reinvestment in other income producing projects. This highly important differentiating feature of the projects is what the decion-maker must fall back upon to reach to an intelligent decision. This is when the discounted cash flow method comes to his aid. The ranking of the three projects is clearly reflected in the discounted cash flow figures, which show 24% for Project A, 15.5%

EXHIBIT 4.4 INTERPOLATION OF THE PROFITABILITY INDEX
(filled in for sample investment)



TRIAL NO.	INTEREST RATE	RATIO A/B
1	0%	.25
2	10%	.63
3	15%	.90
4	25%	1.57
5	40%	2.80

Source: Ray I. Reul, "Profitability Index for Investments", Harvard Business Review, July-August, 1957, p. 54

for Project B, and 13% for Project C.

It is now apparent that the discounted cash flow method is a more refined technique. It takes into account three important variables in the capital investment decision-making: (a) Cash outlay which may be phased over an extended period of time (b) the full length of time over which the income from the investment will flow in and (c) the pattern of cash inflow, as distinct from the implicit assumption of a more or less even cash inflow of the payoff period approach. In other words, the technique is particularly designed to handle varied patterns of cash inflow as well as the cash of uniform cash inflow and to extend up to the end of the investment and not just up to the payoff point. By introducing the discount factor in the calculation, it is also superior to the book rate of return method. Indeed, payback period represents one extreme, since all proceeds received before the payback period are counted as equals, and all proceeds received after the payback period are ignored completely. In the other methods analysed, the proceeds are related by simple averaging technique to such things the original or average cost of investment, its book value and the number of years over which the proceeds were received. None of these methods succeeded in bringing fully the "time" to bear upon the decision process.

It is interesting to compare the rate of return of the discounted cash flow method with the rates from the other methods. Exhibit 4.5 shows cases of varying patterns of cash inflow from a given investment project, Since they relate to the same project, total cash recovery in each case is the same - to put it differently, the area under each curve is the same. The first figure show even cash inflow, the generally implied assumption behind the payoff method, and the figure may be taken as depicting the payback picture of the project. The second figure shows successively smaller or greater cash inflow over the life of the project. The third figure shows irregular cash recovery.

Taking the first figure to depict of a payoff situation, we can compare this with the second figure, typical of situation of discounted cash flow. Clearly, when the cash inflow is decreasing, the rate of return by the discounted cash technique will be higher than the rate implied in the payoff situation (figure 1). The reverse will be the case in relation to the rising

EXHIBIT 4.5

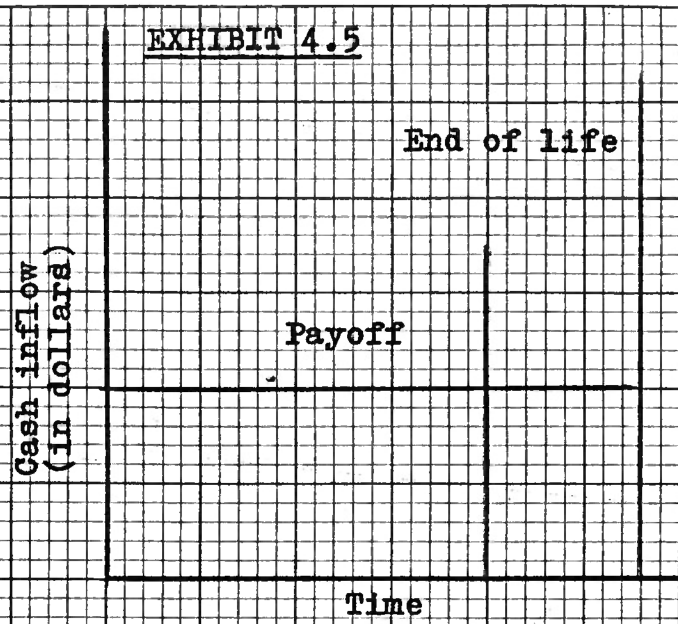


Figure 1

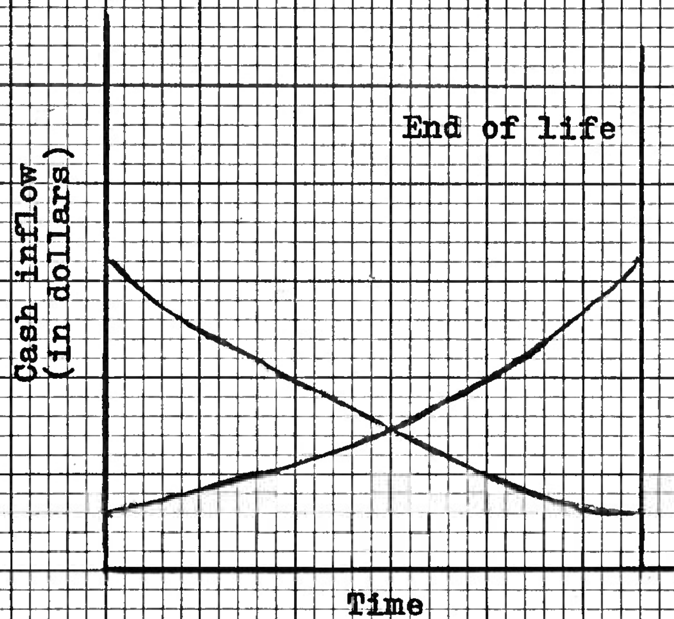


Figure 2

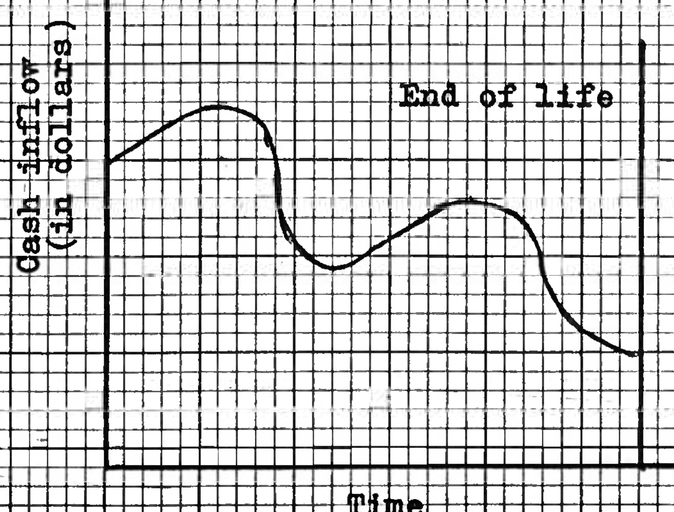


Figure 3

Source: Erwin Esser Nemmers, "Managerial Economics"
(New York: John Wiley & Sons, Inc., 1962), p.359

pattern of cash inflow. All this is due to cash recovery in the earlier period being much faster or slower than the even recovery in the first figure. What happens when the irregular recovery pattern prevails? (figure 3) Compared to the situations in figure 1 and 2, it may be observed that "detailed computations are necessary to determine whether the rate of return to be expected is higher or lower than in the situations illustrated by other two figures".[10] When the rates of returns computed by the discounted method is compared with the book or accounting return on investment, it is evident that the latter will almost always show a higher rate than the former.

The Yield Versus Present Value Method

The discounted cash flow method that we have examined is also called the "yield method" or "investor's method" and is often distinguished from the "present value method" or more aptly termed the "net present value method". The distinction is basically more formal than real. It is well that this be explained - if only to further elucidate the nature of the discounted cash flow method.

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[10]Erwin Esser Nemmers, "Managerial Economics", (New York: John Wiley & Sons, Inc., 1962), p.361

The yield method computes rate of return by discounting cash receipts and outlays of different time period which will equate their present values at a common point of time. Thus, this rate of return is an internal rate of return - internal to an individual business and makes no use of the market rate of return or cost of capital. Different projects thus yield different rates of return and are ranked accordingly. On the other hand, the net present value starts with the market cost of capital or market rate of return and applies this rate to discount the streams of both cash outlays and cash receipts to a common point of time. The excess of cash received so discounted over the cash outlays so discounted is the "net present value". Proposed projects are then ranked by the sizes of their net present values. In one case, in yield method, we obtain rate of return; whereas in the other, the rate is taken from the market and present values are arrived at.

Does the two methods give different ranking to the projects? If so, what then? Harold Bierman and Seymour Smidt [11] observe, "there are situations where the yield method may lead to different decisions than

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[11] Bierman and Smidt, op. cit., p.39

those obtained by using the present value procedure. When the two methods lead to different decisions, the present value method tends to give better decisions". Unfortunately, this assertion is not supported. More than that, these authors further on make an apparently contradictory remark, "it is possible to use the yield method in such a way that it gives the same results as the present value method". As Nemmers[12] has done, one is inclined to accept the second rather than the first observation. Except for extremely hypothetical situations, it is unthinkable that the two approaches - yield method and present value method - would give different ranking of the projects in a practical situation.

Discounted Cash Flow Method: A Rejoinder

Most dynamic of the methods for appraising the investment worth, it would appear to have three shortcomings. Firstly, the trial and error method of discounting cash flow is all too complicated. Secondly, the method assumes that the cash inflows from the capital investment goes to work at the same rate as that applied for the project, on the contrary, the release of cash from the sunk investment, being no longer

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[12] Nemmers, op. cit.,

tied in the specific project should be considered earning at a rate applicable to the total operation of the enterprise. Thirdly, what of the incremental cash income from the reinvestment of the cash inflow in the interim period - that from the date of cash generation to when the life of the capital project would come to an end? Surely the cash flows are employed for the general purposes of the business and earn accordingly. If these contentions are correct, the discounted cash flow or present value approach needs to be more refined. In other words, the compound interest factors used in discounting are not realistic. On this, Robert H. Baldwin has the following to say:

> The future receipts and payments are reduced to their present value by discounting them at the same rate as that which the proposed investment is estimated to provide. In other words, management assumes that, for the period between the base point and the time when the funds are spent or collected, the funds are, or could be, invested at the rate of return being calculated for the proposal.
>
> This is simply not true. Indeed, it is only by coincidence that the two would be at all alike. The funds would be at work during the interim period not at a rate similar to that of proposed investment, but at the average rate at which general corporate funds are being

> invested - at the over all value of money to the company. An appraisal must be made by the management as to what this value of money is now and what it is expected to be in the near future. What is the average return that will be gained on funds drawn from the melting pot of the company treasury? It is at this rate that future cash flow must be discounted to reflect its present value in terms of the realities of the particular company's operations. To do otherwise is to deny management an effective economic appraisal of a proposed investment with which it can make a sound decision and, worse, yet, to substitute an inacurate and probably misleading measure - misleading because it is built on earning multiples which are inconsistent with facts.
>
> ... compounded interest factors in discounting the direct income automatically provides for the reinvestment factor, but such incremental income is determined at the interest rate estimated for the proposal. In actuality, this income is not being reinvested in the original project, and it is unlikely that whatever it is invested in will bring the same return as the original project. Instead, it will be invested one, two, three, or more years from now for general corporate purposes at the average value of money to the company.[13]

How to meet the shortcomings of the discounted cash flow method? What is required is that instead of a constant compound interest factor applicable to the proposal, efforts must be made to introduce the earning rate of corporation (value of money to the corporation) as a whole. As Baldwin has pointed out the interest

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[13]Baldwin, op.cit.p.99

rate to be brought into the calculation should be "one which is consistent with the actual operation of a business enterprise ... not based on a discount rate that bears no relation to the financial performance ..."[14] How can the real rate of return be incorporated in the present value concept. Baldwin demonstrates the method by an illustration.[15] Basically, the streams of earnings are compounded up to the time when the project would have come to an end. The compound factor is the net profit as a percentage of the average total assets (value of money to the business) of the enterprise. With this compound rate the future values of the cash income from the investment project are computed and added up - the point in the future is the year when the investment life would come to an end. This is how the cash inflow from the investment project is suggested to be handled. On the other hand, the phased capital outlay is discounted at the same rate to their present value - namely, the value at the date when the capital project started. The computation thus gives the outlay in dollars on the start of the project, and the total income - the direct cash income from the investment plus the added income or "compounded interest" - in dollar amount at

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[14] Ibid.

[15] Ibid.

the end of the project. Given these two amounts and the time interval the rate of return is easily determined - the rate being the rate per cent at which the first will grow into the second over the given period of time.

What data are required to compute the rate of return in the manner suggested above? They are four: (1) the net investment, net of any recovery while the outlay is being recovered, (2) cash income, (3) the economic life of the project and (4) the value of money to the company or the composite annual return that the business can expect to gain on its invested funds as a per cent of investment.

Summing up, the new approach to present value method is at once simple, direct and realistic. Simple because there is no trial error approach and no discounting of individual stream of earnings and outlay in any complicated manner, as required in the conventional present value method. It is direct because all that is finally required is to compare two dollar amounts, one in the present and the other at the end of the project life to compute rate of return. It is realistic because it works with the realistic earning rate of the business as a whole, currently and/or in expected future times.

MAPI TECHNIQUE:

In the area of capital investment, replacement of equipment is one of the most frequent decisions that the management is called upon to make. Here, more than any where else the problem of obsolescence plagues the management most. It is to provide a flight from the risk of obsolescence that MAPI method deserves to be considered in this study. For in computing its rate of return MAPI technique gives highest priority to the factor of obsolescence.

MAPI Technique: Nature and Method:

The Machinery and Allied Products Institute (MAPI)[16] has developed a method for evaluating investment decisions known as MAPI technique. Its basic assumption is this: an investment today will face future alternatives which may be better than the second best of today - therefore, the advantage of today's best choice over tomorrow's second best won't be as great as it is over today's second best. On this

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[16] Terborgh, op. cit.

sophisticated reasoning, which has now come under fire, MAPI rate of return tends to be the next year's rate of return. It incorporates the assumption that as a machine ages, it faces decreasing efficiency and becomes obsolete as compared with newer machinery. The method compares investing in a project with going without it for one more year. In other words, it concentrates most of its attention on comparisons for the one year immediately ahead. The feeling is that distant forecasts are not very reliable nor are distant performances very important when we put the things on their present value basis. The MAPI method, therefore, in essence, establishes a concept called "the next year rate of return". This is the return that will be earned from an investment if it is made now rather than waiting for a year. The actual computation is made on the basis of the following basic elements:

1. The first factor in using the MAPI technique is to establish net investment. This is the cost of new machinery (including installation) less the salvage value of the old machine and the money that would have been spent in the next year to maintain the old machine - i.e. any investment avoided by the new

investment.

2. The second factor is to compute the next year operating advantages of the project. This is the sum of possible increases or decreases in revenue plus changes in operating costs resulting from the project for next year. This involves a study of direct and indirect labor saving, maintenance saving, tool and supply, scrap, power, space and other savings.

3. The third factor is to determine the next year capital consumption avoided. This is the fall in the salvage value from holding an existing asset one more year, plus the next year allocation of possible capital additions or renewals.

4. The fourth factor is the next year capital consumption incurred - fall in the use value of the new project next year. This is taken from the established MAPI chart which is the standard for accumulated obsolescence. These charts are derived by combining (a) the rate at which the new project's earnings will decline (due to increased maintenance

etc.), (b) the service life of the new machinery, (c) the final salvage value of the machinery, (d) the income tax rate, (e) the depreciation system used and (f) the cost of capital to the business (which is taken as the weighted average of the interest paid on borrowed funds, and the after tax return on equity earned by the business with the weighting following the debt equity ratio of the business).

5. Finally, there is the next year's tax adjustment - net increase in income tax resulting from the project.

The MAPI method uses a two page standard computing form, which gives the summary of analysis and the MAPI urgency rating on the basis of data relating to the five basic elements just mentioned. These standard forms and illutrative data to fill in the forms will be found in Table 4.3 and 4.4.

In the two tables, the various figures are self-explanatory except for columns D and E of Table 4.4 which refers to a chart. MAPI has three charts to use depending on the asset's projected income or

TABLE 4.3

PROJECT No.______ SHEET 1

SUMMARY OF ANALYSIS
(see accompanying work sheet for detail)

I. REQUIRED INVESTMENT

1	Installed cost of project	$ 26,000	1
2	Disposal value of asset to be retired by project		2
3	Capital additions required in absence of project		3
4	Investment released or avoided by project (2+3)		4
5	Net investment required (1-4)	$ 26,000	5

II. NEXT YEAR ADVANTAGE FROM PROJECT
A. Operating advantage
(use first year of project operation)*

6	Assumed operating rate of project (hours per year)		1,200	6
	Effect of project on revenue	$Increase	$Decrease	
7	From change in quality of product			7
8	From change in volume of output			8
9	Total	A	B	9
	Effect of project on operating cost			
10	Direct labor	$ 600	$	10
11	Indirect labor	130		11
12	Fringe benefits	150		12
13	Maintenance	150		13
14	Tooling	50		14
15	Supplies		24,900	15
16	Scrap and rework			16
17	Downtime			17
18	Power	30		18
19	Floor space		3,500	19
20	Property taxes and insurance	270		20
21	Subcontracting			21
22	Inventory		950	22
23	Safety			23
24	Flexibility			24
25	Other			25
26	Total	$1,380 A	$29,350 B	26
27	Net increase in revenue (9A-9B)		$	27
28	Net decrease in operation cost (26B-26A)		$27,970	28
29	Next-year operating advantage (27+28)		$27,970	29

B. Non-operating advantage
(use only if there is an entry in line 4)

30	Next year capital consumption avoided by project:		30
	A. Decline of disposal value during the year	$	A
	B. Next-year allocation of capital additions	$	B
	Total	$	

C. TOTAL ADVANTAGE

31	Total next-year advantage from project (29+30)	$27,970	31

TABLE 4.4

PROJECT No.________ SHEET 2

III. COMPUTATION OF MAPI URGENCY RATING

32 Total next-year advantage after income tax (31-tax) $13,865 32
33 MAPI Chart allowance for project (total of column F, below) $ 995* 33

(enter depreciable assets only)

Item of Group	Installed Cost of Item or Group	Estimated Service Life (Years)	Estimated Terminal Salvage (Percent of cost)	MAPI Chart Number	Chart Percentage	Chart Percentage x cost (E x A)
	A	B	C	D	E	F
Box Machine and Box Stitcher	$26,200	13	10	1	3.8	$995
					TOTAL	$995

34 Amount available for return on investment (32-33) $12,870 34
35 MAPI Urgency rating (34÷5).100 % 49 35

*Since the chart allowance does not cover future capital additions to project assets, add an annual proportion of such additions, if any, to the fugure in line 33.

MAPI's equipment replacement analysis form

Source: Franklin G. Moore, "Manufacturing Management", (Homewood: Richard D. Irwin, Inc.), 1961 p.p. 146-147.

savings pattern, whether it will stay the same or go up or down in the future. MAPI chart No.1 shown here (Exhibit 4.6) is the one for a steady savings. It assumes a debt-equity ratio of 25/75, an interest rate of 3% on debt and 10% after tax return on equity. There are two sets of curves, one in heavy lines going upto the left and a thin line set going upto the right. The left set is for users of sums of the digits or double declining balance method of depreciation, and the right set is for straight line depreciation users.

Column D tells which chart number to use. Column E is a value read off the chart. In our example we have picked up an asset with a thirteen year life, and a 10 per cent salvage value at the end of its life. We may read the chart across the bottom on the bold face type scale to thirteen years, and read up to the heavy curved line for 10 per cent. From the intersection by reading across to the left vertical scale, we find 3.8 per cent. This is the figure in column E in the MAPI calculating form in Table 4.4.

The rest of the MAPI calculating form is self explanatory and on line 35 we end up with the rate of return for the project for the next year.

EXHIBIT 4.6

MAPI Chart Number 1 (Projection Pattern: Standard)

Instructions: (1) Use heavy curves for sum-of-digits or double-rate declining-balance tax depreciation, light curves for straight-line tax depreciation. (2) Locate service life (in years) on horizontal axis, reading from left to right for heavy curves, from right to left for light curves. (3) Ascend vertical line of service life to point representing salvage ratio (estimate location when rate falls between curves). (4) Move horizontally to read point on nearest vertical scale; this is the chart percentage.

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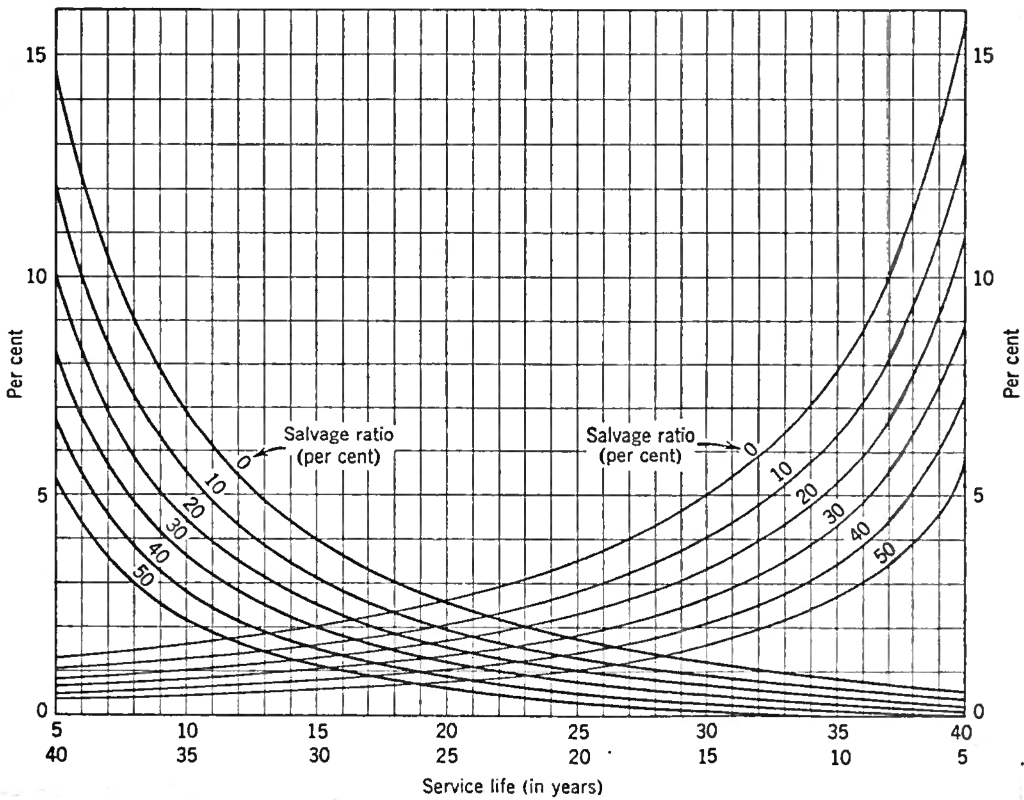

Source: Erwin Esser Nemmers, "Managerial Economics", (New York: John Wiley & Sons, Inc,1962), p. 377

Returning to the basic elements of MAPI approach it may be mentioned that what it does is really to compute a sort of after-tax rate of return. Basically, the computation is as follows:

$$\text{After-tax return} = \frac{\text{Net monetary advantage from project}}{\text{Net investment required by project}} \times 100$$

$$= \frac{(2) + (3) - (4) - (5)}{(1)} \times 100$$

where the numerals denote the different basic elements mentioned earlier.

MAPI Technique: An Appraisal

The greatest objection to MAPI method is that it can be applied only to replacement investment proposals. And since these represent only a small part of total investment opportunities, it can not be considered a universally applicable yardstick. It is also alleged that the assumptions necessary to make its application practical are completely unrealistic.[17] It is assumed: "if you don't replace a machine this year but instead, wait a year, then some other still

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[17]For complete discussion on the alleged objections see Joel Dean and Winfield smith, "Has MAPI a Place in a Comprehensive System of Capital Control," The Management of Corporate Capital, ed. Ezra Solomon (Illinois: The Free Press of Glancoe, 1959), pp. 293-306.

newer and more efficient alternative will be available .. and possible still newer alternatives are assumed to be improved more and more." It is this assumption that is being questioned. Technological growth does not proceed in such ready and progressive fashion. There is no need to take such a short view of capital investment problem. Many other assumptions under the MAPI formula : (1) repairs to equipment increase with age and (2) 25% of capital for the investment is borrowed at 3%, while the owner's equity is imputed a 10% investment rate. These assumptions are also obviously subject to dispute.

A Verdict on the Techniques

Summing up the chapter, it may be observed that we have made a comparative study of the nature, scope of application and the merits and demerits of a wide variety of quantitive methods to appraise capital investment projects in business. Though thses techniques can take care of varying degrees of complexities, dollar commitment and service life of these projects, no attempt was made to discuss in detail the applicability or relevance of the techniques in relation to the specific types of capital investment found in a typical business enterprise. For the same reason, no attempt was made to present the minor variations of these different methods discussed in the chapter.

In view of the foregoing, it is interesting to present data on the extent of the use of the different techniques in the modern industry. Here is the finding of a fairly large and more recent survey of 127 industrial corporations made by Systems and Procedure Association in 1960:

TABLE 4.5[18]

Prevalence and functions of different techniques

	Percent
Payout period alone	14
Payout period with rate of return ...	38
Average rate of return on original cost of investment	46
Discounted cash flow (time discounting)	30
Total using either form of rate of return standard in investment decision-making	77
Other uses of rate of return measurements:	
Check of realized against forecast rate of return on investment	57
Setting profit goals	56-60
Determining management incentive payments	25
Guide to size of inventory	22
Product price fixing	27

[18] William H. White, "The Changing Criterion in Investment Planning" (Washington DC: The Brookings Institution, 1962), p.10.

What word of final verdict can be uttered on these different techniques? To answer in the words of William H. White:

> The most universal standard employed by enlightened managements is the return on investment the project will produce. ... Well managed companies of the future will be those that have established profit criterion and stick to them. With enlightened managements found relatively more frequently among larger firms and with the return criterion presumably in wider use for expension than for new product investment, this survey constitutes very strong evidence for the pervasiveness and the precision of the return criterion.[19]

Howsoever widely prevalent may be the use of one or the other technique, whatsoever the preciseness of the investment criterion that one or other may provide - all of them in final analysis are as good as the data they work with - the data relative to the future - since capital investment, by its very nature, must look into the future. It must, therefore, be added: how good are they - the data - in a decisional situation of the present? What about the uncertainty that must necessarily breathe through them? How appraise uncertainty and merge it into the decision-making complex? For this, we turn to the next chapter.

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[19] *Ibid.*, p. 11

CHAPTER V

UNCERTAINTY AND INVESTMENT DECISION MAKING

In Chapter II, we gave a thumb-nail sketch of the profile of capital investments in business. Evidently, capital investment projects, in practice, may range from a few hundred dollars to a few million dollars, from the simplest routine types, such as equipment replacement to the most strategic variety that reduces the overall riskiness of the enterprise. In Chapter IV, we studied a variety of techniques, more or less elaborate mathematical models or formulas, for comparing the merits of different investment projects - models that are also capable of comprehending the variables affecting each of them. Indeed, as these techniques have developed, their mathematics have become more and more precise so that today we can calculate the rate of return or earnings power and/or payoff periods of different projects almost to a fraction.

All these aforesaid techniques implicitly work with exact and unique values or data, such as exact cash flows through time, definite magnitude of demand, competitiveness etc., that lie at the back of them all.

It is now necessary to raise the question: can the project-ranking, in practice, proceed on such an assumption? Any experienced management knows that behind the precise calculations are data which are not that precise. At best, they are based on an average of different opinions with varying degrees of reliabilities. Even otherwise, the decision-maker cannot obviously be exactly sure of all the future events which will affect the outcome of each alternative investment projects. He cannot know how consumer tastes and demands will actually be in the distant future. He cannot exactly know what new competition will emerge in the market and with what intensity, what new substitutes will appear, or what new technological developments will alter his environment and so on. It is true that more experienced the decision-maker, more knowledgeable he is, more accurately he may peer in future - but never can he get to the point of being exact, sure and definite. On the contrary, the more distant is the future, he looks into, less accurate he must be. To put the point more categorically, the data he deals are not what <u>he knows</u> of but what <u>he expects</u> to happen.

More than in any other instance, decision-making in capital investment, in the nature of things, must obviously look into the future and hence run into the expectations. The larger the project and larger the period of amortization the larger is the role of expectation in the decision-process. It is this element of expectation that introduces uncertainty as the strategic factor in the capital investment decision process. What precisely is its nature and scope in capital investment decision-making? How can this uncertainty be integrated into the actual decisional process? These are the questions that this chapter will deal with.

Nature and Scope of Uncertainty:

When the relevant facts or data are not known or imperfectly known, we have the situation of uncertainty. It is the reverse of perfect knowledge of what the statisticians call "the state of nature" or the background of decision-making.[1] It is uncertainty that causes the spread between what decision-maker expect to happen and what actually does happen. This

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[1]For different kinds of risk and uncertainty see Frank H. Knight, "Risk, Uncertainty and Profits" (Boston: Houghton Mifflin Company, 1921), p. 233.

is a situation when the decision-maker places bets hoping that he will win but knowing that he may lose. Under such circumstances, a right decision consists of the choice of the best possible bet, whether it is won or lost after the fact.

The uncertainty in investment decision occurs because we cannot assign a unique set of cash flows to a particular investment project as there are several conceivable outcomes of the investment depending on events which may occur. In practice, businessmen are seldom, if ever, certain of cash flows likely to result from a particular investment. The uncertainty arises from the fact that we do not know for certain which of the possible events will occur, and thus cannot be sure which cash forecast would be found to be correct.

How does uncertainty cast its shadows on the capital investment decision-making? The question may be answered by an illustration. Suppose a manufacturer is about to tool up for production of a newly developed product. This product may be manufactured by either of two process, one of which requires a relatively small investment but high labor costs per unit produced while the other will have much lower labor costs but requires a much greater investment. The former process thus will be the better one if sales of the product are low while the latter will be better if sales are high. The demand of the product is very sensitive to general business conditions. If general business conditions are good, the demand for the product is likely to be high whereas if the general business conditions are poor the demand will be low. Which way would the background or "state of nature" - namely, the business condition - go? Under such circumstances the cash flows the two investment projects cannot be precisely predicted because of the uncertainty of the future general business conditions, in its turn, the decision-making has to contend with uncertainty. If the future state of general business conditions could be perfectly forecasted, then the outcome of the investment could be predicted.

It is interesting to mention here that from the point of view of decision-making, conditions of uncertainty may be classified into three categories: one, where the possible "states of nature", providing the decisional frame, are subject to control of an adverse intellect, such as might be the case in situation of oligopoly; two, where the states of nature are probablistic rather than certain; and three, where there is an altogether complete ignorance of the states of nature. The decision-making under these three conditions are often described as decision-making under conflict, risk and ignorance respectively.

Which of these uncertainties are particularly relevant in capital investment decision-making? Very rarely does a management make any long-term capital investment without some knowledge. If no prior knowledge is available, pilot or trial projects or studies are often run to enable the management inform itself. Concerned with fairly long horizon, capital investment problem would very rarely be viewed in the perspective of uncertainty of conflict. As economy theory of oligopoly explains, the conflict is essentially a short run phenomenon. It may, therefore, be concluded that the uncertainties characterising capital investment problems are essentially probablistic in nature and content - calling for decision-making under risk. It is with this facet of uncertainty that we will be concerned with in rest of the chapter.

<u>Probability and Uncertainty</u>

Probability measures the chance of a particular event happening from amongst a set of mutually exclusive and collectively exhaustive events. More simply, probability may be defined as a measure of opinion about the likelihood that an event will occur. If we believe that an event is certain to occur then we say that it has a probability of one. On the otherhand, if we believe that an event is certain not to occur then we say that its probability of occuring is zero. Generally we are concerned with events whose probability of occurance is somewhere between zero and one. When we say that probability that a tossed coin will come up with "heads" is .5 it is because in the long run, and in a fairly large number of trials, we will have "heads" half the time. In other words, if there are say 100,000 tosses of a coin, we can predict that heads will appear approximately half of the time. It may be added that the toss being capable of repeated experiments, the probability is objective and varifiable. With limited number of tosses, the <u>actual</u> number of heads may differ significantly from the <u>expected</u> number of heads. How is the probability measured in business situations?

Let us suppose, two oil companies, small and large, decided to drill one oil well and fifty oil wells respectively. We shall assume that based on experience, oil companies have the same probability of finding a productive well which is .10. The probability of small oil company drilling one well to find "no oil" and face ruin is, therefore, (1-.10) or .90. The large company's chance of finding "no oil" at all, on the otherhand, is $.90^{50}$ or .0052. The probability of a success or failure for a single well is the same for both the companies, but the probability of facing complete failure is greatly different in the two cases. Similarly, the chances of some success for the small company is .10 whereas for the large company, it is (1-.0052) or .9948.

At this stage, a few specific points may be made. Firstly, eventhough the outcome of a particular decision may be highly uncertain, if a large number of identical decisions are made, it may turn out that we can predict certain characterstics of the outcomes of the whole collections of decisions with relatively little uncertainty. Though undertaking several investments tends to reduce the range of possible outcomes, some uncertainty will remain. Secondly, there is more uncertainty about the amount of oil that will be discovered per dollar of investment if a given amount is invested in drilling one well than if the same amount is invested in shares of fifty separate drilling operations. Thirdly, the return on our investment will depend not just on how much oil is discovered but on how much oil is worth. A change in the level of world oil prices - change in what we called the "state of nature" - will have nearly the same effect on the value of a given amount of oil reserves, whether the oil has been obtained by drilling one well or fifty. The element of uncertainty is seldom, if ever, completely eliminated as a factor affecting business investment decisions.

If the concept of probability were applicable only to uncertain events that could be repeated a large number of times under controlled circumstances, like tossing a coin, the concept would be relatively of little use in analysing business investment decisions. Most investment decisions are unique in that one does not make the same decision in essentially the same circumstances. If a businessman is considering opening a drugstore in a certain location, there may be a great deal of evidence that helps him form a judgement that a drugstore in that particular location could be profitable. But since there is no other location and period of time that is exactly the same in all respects as the location and time he presently has in mind, the businessman cannot resort to an objective measure of profitability. However, a useful measure of subjective probability may be applied to such situations, namely probability that measure the state of belief of the person who makes the estimate. This in turn, may be based on the experience of the person concerned and may be used in making decisions to be consistent with these beliefs.

By and large, it is this kind of probability - more subjective than objective - that becomes relevant in handling uncertain events affecting the large number of business decisions, more specially the capital investment decisions that we are concerned with. This so because no two environments of decision-making in capital investment can ever be identical. Business realities do not repeat themselves as do the conditions of tossing of a coin.

It may well be asked: is not subjective probability a matter of individual opinion and arbitrary assignment of numbers between zero and one to an event? This is not so. The businessman has considerable knowledge and experience in his field. Where he does not have any, he develops through pilot study or research or experiment, as the situation may demand. Indeed, Robert Schlaifer explains how and why subjective probability is not so:

> The theory of probability does not replace judgement and experience. Its utility lies rather than in the fact that it allows to make more effective use of our judgement and experience by assigning probabilities to those events on which our experience and judgement bear most directly rather than to events which will actually determine costs but with which we have had relatively little direct experience.[2]

In other words, subjective probability is essentially the resultent of experience and judgement of the decision-maker and not "irrational" whim of the top executive.

Decision-Making with Probabilities

It is well to recognize that management can reduce

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[2]Robert Schlaifer, "Introduction to Statistics for Business Decisions" (New York: McGraw-Hill Book Company, Inc., 1961), p. 192.

uncertainty in variety of ways.[3] The choice of the appropriate approach is itself an important business decision. Information varies in degree from the situations at one extreme, in which uncertainty is so insignificant that it is convenient to ignore it, to the situations at the other extreme, in which it is so great that choices can be little more than random selections. The analysis of uncertainty becomes more profitable between those extremes. Whatever devices are used for reducing uncertainty management cannot eliminate it altogether. Given this consideration, the nature of probability and the problems of capital investment, the question then becomes one of applying probability analysis to the remaining uncertainty. Many managers are skeptical about applying formal probability analysis to cases of uncertainty; many statisticians are also doubtful about the theoritical basis for such analysis. The trend, however, appears to be in favor of integrating probability theorems into decision-making.

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[3]For different methods of dealing with uncertainty, see William Warren Haynes, "Managerial Economics" (Homewood: The Dorsey Press, Inc., 1963), p. 557.

Clearly, the probability evaluation of uncertain events affecting the outcome of investment decisions should help us to integrate "uncertainty" into the decisional process. There is, however, one preliminary point that need to be clerified before we can proceed. The nature of probability relevant for our purpose, as mentioned earlier, would depend on "judgement" in the sense that two reasonable men may well assign different values. Unless ways can be found to merge the "judgement" into a single evaluation, the theorems of probability would be of no avail to decision-maker. How can this be done?

The broad answer, which has since been generally accepted, is indicated by the path-breaking approach by Schlaifer.[4] Firstly, the businessman can take note of his varied experiences and judgement by averaging them according to statistical methods. He does not have to take any one to the exclusion of others. This is what Schlaifer calls assessment of probabilities by smoothing historical frequencies. Secondly, in the

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[4] Schlaifer, op. cit.

light of new and additional informations available to him on the eve of decision-making, it is open to the decision-maker to revise his probabilities. Schlaifer[5] gives a number of realistic illustrations, to explain how these may be done.

How can the probabilities be made to "merge into" decision-making? The steps in the integration process consists of (a) making use of the laws of probabilities, (b) computing a payoff table of the monetary outcome of different combination of future events and the present acts of decisions and (c) using the same to build up an expected monetary value metrix by interjecting the probability distribution in to the payoff table. The entire process may be explained by taking up a single illustration.

Illustration of Decision-Making Under Uncertainty

To illustrate decision-making under uncertainty, we may return to our example of producing a newly developed product by either of the two processes; one of which requires a relatively small investment but higher labor cost per unit produced, while the other

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[5] *Ibid.*, chapters VII and XII

will have much lower labor costs but requires a much greater investment (we shall call them manufacturing Plan A and Plan B respectively). Let us suppose there is a possibility of occuring four different sales events. The outcome of these events will obviously be different, which we have complied in Table 5.1 (minus signs denote losses). The management has to decide whether to adopt manufacturing Plan A or Plan B or none. The table indicates the payoff of alternative decisions under varying conditions of sales events coming true.

TABLE 5.1

Payoff Table for the Manufacturing Example

	Managerial Decision	
	Conditional returns	
Sales event	Plan A	Plan B
A	$ 1,000	$-15,000
B	4,000	4,000
C	7,000	12,000
D	11,000	20,000

The first step is to determine the probabilities of each event. At this point the decision-maker would want to use as much information on past experience and future prospects as possible. In the absence of all the information, subjective probabilities may be assigned.[6] Suppose on the basis of market research and other statistical experiments, probabilities shown in Table 5.2 have been assigned to all the four different events. The probability-weighted expected monetary value is also shown in the table. Now this problem can be solved by using the expected monetary value. The expected monetary value of an act is a weighted average of the conditional monetary consequences of that act, using the probabilities assigned to events as the weights. The alternative which has the highest expected monetary value should be accepted. The table 5.2 shows the calculation of the expected monetary value.

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[6]The time and the competence of the author does not permit to deal with the subject of the mathematics of probability exhaustively. We assume that for the purpose of assigning the probabilities data are available to estimate the relative frequency of occurance of the event in the long run if successive trials of the events are made "under the same essential conditions". Where no such data are available, we suggest to use analysis based on the concept of sensitivity. Many modern writers on statistical decision theory and operation research advocate the use of probabilities obtained through intuition in cases where no data are available to estimate relative frequencies in the long run. For a clear exposition of a case for the use of such 'personal' probabilities in decision making, see Robert Schlaifer, "<u>Probability and Statistics for Business Decisions</u>" (New York: Mc-Graw-Hill Book Company, Inc., 1959).

TABLE 5.2

Computation of the Expected Monetary Value

		Managerial Decision			
		Plan A		Plan B	
Sales Events	Probabilities	Conditional Monetary Value	Expected Monetary Value (2 x 3)	Conditional Monetary Value	Expected Monetary Value (2 x 5)
1	2	3	4	5	6
A	.1	$ 1,000	$ 100	$ -15,000	$ -1,500
B	.4	4,000	1,600	4,000	1,600
C	.4	7,000	2,800	12,000	4,800
D	.1	11,000	1,100	20,000	2,000
			5,600		6,900

Clearly, in the above situation Plan B must be adopted as it has higher expected monetary value than Plan A. Question may be asked how does the probabilities help us to reach to the right decision? The answer is simple to offer: the probability analysis focuses on the events for which there is a greater possibility to occur and automatically adjusts the outcome of other events (favorable or unfavorable) the occurrance of which is also possible. Naturally our analysis is refined as we not only consider the profits which may be received on the happening of a particular event, but also the probability of hapening of that event. We may examine this by assigning different probabilities to the events in the above example.

Suppose the probabilities of events were different for example, .6 for A, .2 for B and .1 for C and D each. Do we still adopt Plan B? The answer is "no" and may be verified by expected monetary value on the basis of new probabilities as shown in Table 5.3.

TABLE 5.3

Computation of the Expected Monetary Value

		Managerial Decision			
		Plan A		Plan B	
Sales Events	Probabilities	Conditional Monetary Value	Expected Monetary Value (2 x 3)	Conditional Monetary Value	Expected Monetary Value (2 x 3)
1	2	3	4	5	6
A	.6	$ 1,000	$ 600	$-15,000	-9,000
B	.2	4,000	800	4,000	800
C	.1	7,000	700	12,000	1,200
D	.1	11,000	1,100	20,000	2,000
			3,200		-5,000

With the distribution of above probabilities, clearly Plan A instead of Plan B must be adopted.

To sum up: expected monetary value of an act or decision is a weighted average of all the conditional values of the act, each conditional value being weighted by its probability - conditional value of an act, in turn, being the consequence resulting from the act given a particular event occuring.

Applicability of the Technique

Let us look at the expected monetary values of the two projects in the table. What does the Plan A mean? The expected earnings is an average view of the earnings project. In actuality, the earnings could be as low as $1,000 or as high as $11,000. Should the earnings be as low as $1,000, what then? Could the decision-maker afford to take this risk? This brings us to raise the question: how generally is valid "the expected monetary value" as a guide to action? The frame of this question may be exemplified. Consider two businessmen each of whom believes that if he submits the proper proposal he has a 50-50 chance of being awarded a contract which is sure to yield a 35,000 dollars gross profits, and suppose that preparation of the proposal will cost either of these men $10,000 out of pocket. The expected monetary value of the act "summit the proposal" is shown in Table 5.4 to be a positive $ 7,500 for either of these two men while

TABLE 5.4

Expected Monetary Value of Making the Proposal

Event	Probability	Monetary Value: Conditional	Monetary Value: Expected
Get contract	.5	$ +25,000	$ +12,500
Do not get contract	.5	-10,000	- 5,000
			+ 7,500

the corresponding figure for not making the proposal is obviously $0, and yet the two men may quite reasonably come to opposite conclusions. If one of them is extremely hard pressed for cash and could easily be bankrupted by the loss of $10,000, he may well decide to let this opportunity go; if the other man has adequate working capital he may with equally good reason decide to make the proposal.[7]

What is the point of this example? Obviously, there are situations in which expected monetary value

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[7]Illustration adopted from Schlaifer, _op. cit._, p.26

is not a valid guide to action - perfectly in accord with the particular decision-maker's own judgement and preferences. For, what is more involved in the decision is just this: is it worth risking a loss of $10,000 in order to have an even chance of a $25,000 profit? Surely, the decision can't turn on any sophisticated or conceivable computation; on the contrary, it _must_ turn _entirely_ on a direct expression of personal preference of the decision-maker or investor. That the expected monetary value is not a universally valid guide to action shall be obvious. Schlaifer has this to say on the test of the validity of expected monetary value as guide to action:

> Expected monetary value should be used as the decision criterion in any real decision problem, however complex, if the person responsible for decision would use it as his criterion in choosing between (1) an act which is certain to result in receipt or payment of a definite amount of cash and (2) an act which will result in either the _best_ or the _worst_ of all the possible consequences of the real decision problem.
>
> . . . the correctness of this rule can be "proved" in the sense that we can show that any person who does not follow the rule will end up by making choices which in the opinion of most reasonable people are logically inconsistent.[8]

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[8] _Ibid._, p. 29.

Why the "expected monetary value" criterion is not valid in all situations? It is not because of any inherent deficiency of the criterion but because of the individual's attitude towards risk.

<u>Attitudes Toward Risk: Expected Utility Approach</u>

While the expected monetary value does take into account risks in decision-making, it obviously does so by averaging the acts of each events bearing on the decision. On the other hand, an individual decision maker may do just the opposite. Instead of looking at the average he may weigh the risks of each of the individual items that make up the average. He may look at the scatter of individual risks. Accordingly, he may be more gripped with the fear of loss than with the hope of gain. To put the point in terms of earlier example, he may be more discouraged by the fear of losing $10,000 than encouraged by the hope of gaining $25,000. Another individual looking at the same problem may view it in just the opposite way. What makes for this varying attitude towards risk? In risk, what is at stake is money, and the value of money is not the same for all. To the rich man with his large cash holding the value of the money is less than what it is to the poorer man with his less cash balances.

Given these considerations, a decision-maker's attitude towards risk becomes a factor in the decision making. Accordingly, before a sound decision is possible each decision-maker (investor) must measure his own utility of losses and incomes consequent of each of the acts and events. Harold Bierman and Seymour Smidt have the following to say about the utility function in relation to decision-making:

> It may be possible for an investor to describe objectively his risk preferences. Such a description is called a utility function. Just as subjective probabilities can be used to describe a person's attitude about the likelihood that some outcome will occur, so a utility function may describe his risk preferences.
>
> A utility function assigns a number to each possible outcome of an uncertain event. The number assigned by a utility function can be interpreted as an index of the relative satisfaction the individual would derive if that outcome actually occured.[9]

The difference between the expected monetary value approach and the expected utility approach is obvious. The latter replaces the expected monetary payoff table by a table of expected utilities. One is monetary values times the probabilities of events and the other

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[9]Harold Bierman, Jr., and Smidt, op. cit., p.285.

is utilities times probabilities of events, the utilities being those of the conditional dollar values. Table 5.5 shows the computation and results of utility function in column 5 and 8. The data are those of the Table 5.2 used for the computation of expected monetary value.

TABLE 5.5

Computation of the Utility Function

		Managerial Decision					
		Plan A			Plan B		
Sales Events	Probabilities	Conditional Monetary Value	Conditional Utility	Expected Utility (2x4)	Conditional Monetary Value	Conditional Utility	Expected Utility (2x7)
1	2	3	4	5	6	7	8
A	.1	1,000	10	1	-15,000	300	-30
B	.4	4,000	40	16	4,000	40	16
C	.4	7,000	70	28	12,000	120	48
D	.1	11,000	110	11	20,000	200	20
				56			54

How have the utility values been assigned? Not anyhow, but in a logical manner. In this case, utility is proportional to the quantity. For every $1,000 profit utility value given is 10. On the otherhand, since the investor is very much is averse to any possible loss he might have to incur as he assigns twice as much utility to losses as to profits. The utility function thus accurately describes the marginal utility of money to the investor. As such he will make the choice that provides the highest expected utility, and so select Plan A.

How to develop utility function in practice? Cramer and Smith[10] have applied this approach to evaluation of research and development projects, notably large expenditures with uncertain payoffs running from very high to nil. They derive utility functions (rules for converting dollar estimates to estimated utilities) via the standard - gamble approach. They selected eight executives from a single large company, four from production and four from research and development. They asked each such questions as, "if an investment of $100,000 in a product will result in a payoff of $200,000 or $0, what probability of getting the $200,000 would be just great enough to make the investment of the $100,000 a toss-up decision?

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[10] R. H. Cramer and B. E. Smith, "Decision Models for the selection of Research Projects", The Engineering Economists, (Vol. 9 No. 2, Winter, 1964).

Since the proposition amounts to a zero expected value equal chance of getting or losing $100,000, the answer gives a managerial judgement of the subtraction to be made, because a 50-50 dollar risk is something less than 50-50 when converted to utilities. Similar questions about the break even probability needed to justify a $100,000 investment when patoffs are $300,000 or $0 etc., provided eight sets of estimates relating dollars to utilities. From there on, through a mathematical approach they develop utility values to demonstrate "a possibility of quantifying the conversion from dollars to utility".

A Summing Up:

Of all the decisions, none is more challenging than choosing among alternative capital investment opportunities. As will be evident from the previous chapter, the challenge is not inprojecting the return on investment under any given set of assumptions. The challenge is that "each assumption involves its own degree, often a high degree ... of uncertainty; and taken together, these combined uncertainties multiply into a total uncertainty of critical proportions."[11]

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[11] David B. Hertz, "Risk Analysis in Capital Investment," Harvard Business Review, (Vol.42, No.1, January-February,1964), p.95.

Conscious of the implications of uncertainty in decision-making, management has made many efforts to cope with the situations. Mention may be made of efforts to obtain more accurate forecasts, make more empirical adjustment in the decisional process, use selective higher cutoff rates and avail of what has come to be called "three level estimates". While these efforts to cope with uncertainty have been successful up to a point, all seem to fall short of the work, in one way or another. Regardless of the efficiency of management in obtaining the data and select the decisional criterion, it cannot entirely eliminate uncertainty. It is to these balance uncertainty that we were concerned with in the foregoing pages - what is its nature, what are its implications in decision-making and how can they be given consideration in the decisional process.

The major theme of the chapter was to emphasize the statistical probabilities, type of uncertainties, and demonstrate how through the application of the theorems of probability, the uncertainty could be woven into a decision.

At the conclusion of the chapter a final observation may be made that the use of selected probabilities to handle uncertainty in decision making is not perhaps the only feasible approach. Edward G. Bennion[12] suggests the use of game theory to handle the problem of estimating rate of return in the midst of uncertainties. It is interesting to mention that he too uses probabilities, but those that he estimates from the analytical data of the investment problem itself. L. C. Grant[13] suggests another approach, but does not leave out the concept of probability altogether. Yet again is the kind of approach to uncertainty developed in McKensey & Company[14] taking a range of probability values of each of the nine input factors mentioned in Chapter III and average each of them in terms of their frequency distribution. Taking the values from these distributions the method compute different rates of return. In other words, instead of single probabilities of the appropriate input element, a range of probabilities of them are taken into account. Accordingly, the appraisal leads to a whole range of rates

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12 Ibid., p.99

13 Ibid.

14 Ibid.

of return with varying probabilities of success. They are then set up in a frequency distribution again, and the management obviously choose the one, with the highest ordinate. To put the point differently the computational method assumes a whole range of probabilities of what are relevant to decision-making and in averaging them at the final selective stage they may appear to reduce uncertainty more than some other methods of approach examined in this study.

It will be evident from the brief account of some of the other methods that they all deal with probabilities in one form or another. It may, therefore, be finally observed that the only way to deal with risk and uncertainty is through the application of probabilities; and, hopefully, an application of probabilities will often yield entirely different and better decisions.

CHAPTER VI

CONCLUSION

In business a large variety of capital investments are being constantly undertaken. They may be classified into three broad categories: (1) working capital; (2) long-term fixed intangible and (3) the long-term tangible fixed ones. Of these three, it is the last that provided the perspective to this study.

What are factors that go into the decision-making on these investments? What problems arise in the process? What kind of major tools can the business executive bring to his aid in arriving at his decision? How, in particular, can he handle the uncertainty of of the future in which he finds himself when engaged in his task of decision-making? In the foregoing pages we have tried to delineate the studies and writing on questions in our times. It is hoped that the business executive will come to appreciate that instead of trial and error, hunches or intuition, there are now tools to help him take a scientific approach to the difficult task. No more than in other areas of decision-making can, however, he ask for precise, affirmative and verified answer. For all that he has to wait for the future to move into the present.

Of the utility and versatility of the quantitative techniques in relation to the tangible fixed capital investment decision-making, that has been the subject matter of this study, two final observations may be made:

One: One may doubt if there is any one process that is best for all companies. Differences in size, technological processes, managerial philosophies and other factors are too great. However, there are common thread that run through them all and as such this study cannot be amiss to any one of them.

Two: Management has some hard thinking to do before it is ready for figures and formulas. Even then, the actual decision-making, in capital investment, will ever remain a matter of intelligent compromise - a stradle between just plain hard and expensive effort and the wise interpretation of the almost imponderable mists of any forecast.

Let this study, therefore, be concluded with these words from Ross G. Walker:

Any way we look at it, managerial judgement continues to be the hard core of investment decision-making. But with the help of greatly increased amount of study and writings of recent years on the difficulties and solutions of investment complexities we can now advance our understanding of just what we are able to do that make sense in counseling and channeling this judgement, and of what we are not doing, or cannot do, to give measurable assistence. Success toward this end will go down, in my book, as a real achievement.[1]

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[1]Ross G. Walker, "The Judgement Factor in Investment Decisions," Harvard Business Review, (Vol. 59, No. 2, March-April, 1961), p. 99.

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